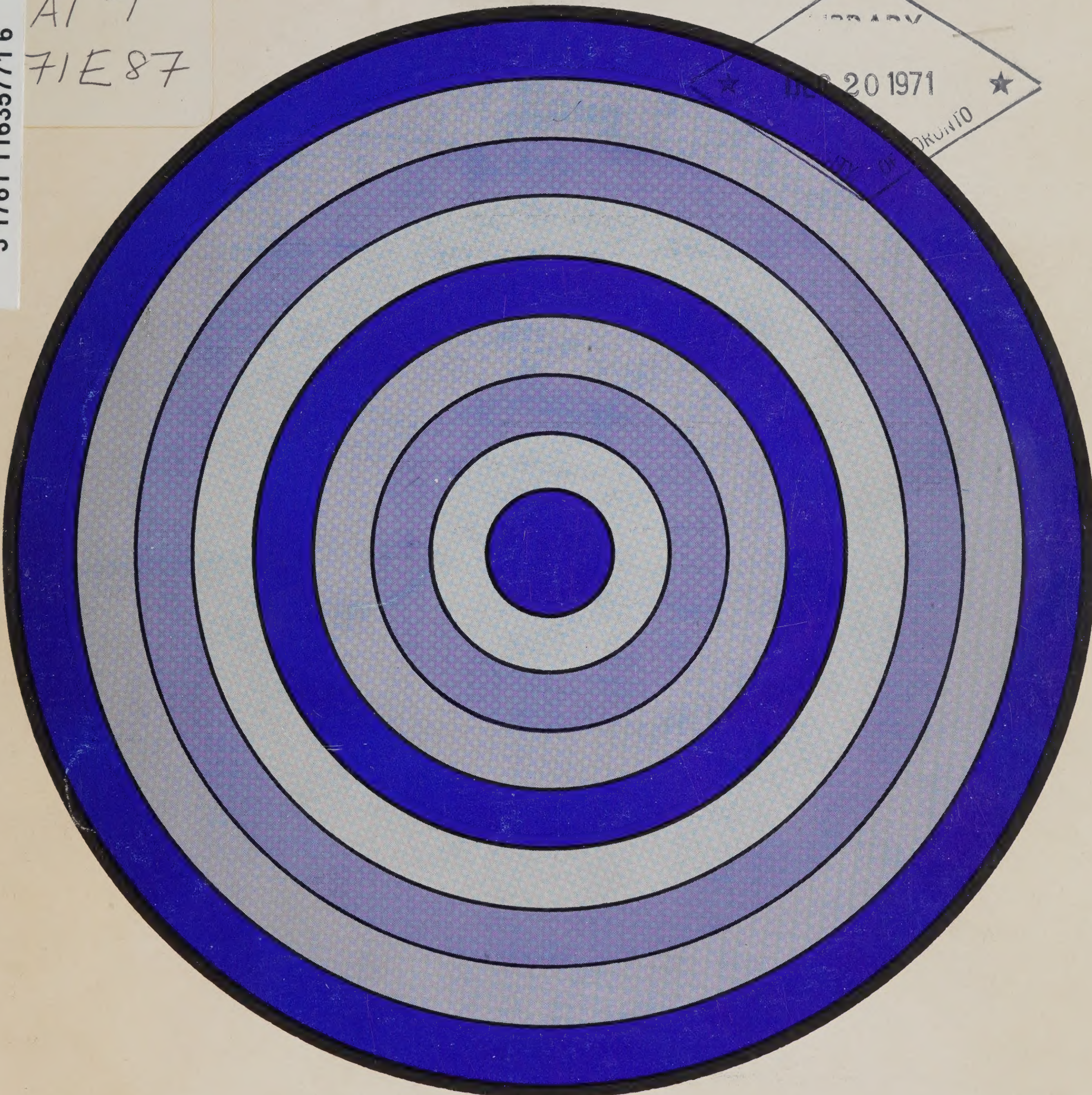
Transport Canada Transports Canada

An Evaluation Of Urban Transport Efficiency In Canada

Évaluation Du Rendement Du Transport Urbain Au Canada



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<6-13> AN EVALUATION OF URBAN TRANSPORT

EFFICIENCY IN CANADA

Dept. of

MINISTRY OF TRANSPORT

GOVERNMENT OF CANADA

SEPTEMBER 1971

LES SOMMAIRE ET CONCLUSIONS SONT INCLUS EN FRANCAIS
A LA FIN DE RAPPORT

THE SUMMARY AND CONCLUSIONS ARE INCLUDED IN FRENCH
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(Bound separately and covering in more detail the findings reported in Chapters 15 to 22.)

1.1 TERMS OF REFERENCE

> "The current tremendous growth of Canadian cities is producing serious urban transportation problems. About three quarters of all Canadians, depend for their livelihood directly upon economic activity in Canada's urban areas. Since urban transportation constitutes about one fifth* of the cost of all urban economic activity, measures to improve the efficiency of urban transportation could be very important and beneficial both to the national economy and to the quality of living of most Canadians.
>
> "Most assaults upon the urban transportation problem have been comparatively narrow and facility oriented. Some useful techniques have been developed for the planning and design of facilities. It is suggested, however, that a new thrust should be directed to a broad community systems evaluation of the influences of urban transportation.
>
> "The objective of this study, therefore, is to evaluate the efficiency of Canadian urban transporation and to identify the ways and means which are most likely to be effective in improving the efficiency."

These paragraphs introduce the proposal of July 29, 1968, which has become the basis of the contract of Nov. 6, 1968, between N. D. Lea & Associates Ltd. and the Queen in right of Canada represented by the Minister of Transport.

The proposal specifies that the approach will use "idealized simplified cities" for simulation of Canada's urban development. "Order of magnitude estimates" and "judgement and experience" are to be

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* This estimate was made before the study. One of the findings of the study as described in Section 4.1 is that urban transport costs are even higher than anticipated.

used to achieve a broad overview of urban transportation in Canada resulting in:

- an estimate of the savings attainable through urban transport improvements,
- a framework for future evaluations, and
- a preliminary evaluation of Canadian urban transport research priorities.

The Nov. 1968 contract specifies a six month duration for the project and gives a modest budget for financing it during this period. The result of the Nov. '68 contract was a draft report produced in July, 1969. A subsequent contract dated June 3, 1970 covered the preparation of a series of technical memoranda and a final report. This document is prepared in compliance with the later contract.

1.2 PROJECT OBJECTIVES

The objectives of the study are:

a) to evaluate the efficiency of Canadian urban transport systems, and
b) to identify the ways and means to improve this efficiency.

1.2.1 Technical

The project seeks a technical evaluation and does not attempt to solve the many political and administrative problems associated with urban transportation. Some basic characteristics of urban transport suggest that administrative problems will persist. For instance, urban transport tends to overflow administrative and jurisdictional boundaries. The omission of political and administrative issues from this study does not constitute any comment on their importance or character, but only defines one limitation of the project as a technical study. The participation of both C.M.H.C. and the Minstry of Transport, through financing and through representation on the steering committee, has aided in giving the desired breadth of technical vision.

1.2.2 Policy Formulation

The project is intended to provide technical data and a technical perspective for policy formulation by interested administrative agencies. In many urban regions there are four levels of government: municipal, metropolitan, provincial and national. At each level many departments or agencies may be involved with urban transport, as listed in Section 5.1, for the Federal Government. The report findings will be of interest to the private sector who also have a very great, but fragmented, interest in urban transport. It is aimed primarily, however, at providing a technical perspective to assist in public policy formulation.

1.2.3 Quality or Level of Living

Specifically included in the project objectives is the obtaining of some measure of the quality or level of living. The recent history of urban transportation in Canada contains many instances of transport decisions being taken contrary to the recommendations of technical reports. In some instances, at least, this is because of a failure of the technical reports to adequately consider the social issues. Consider the case of urban freeways. Many technical reports have presented strong technical cases for the construction of freeway projects, but the democratic decision process has disregarded many of these recommendations apparently because the technical evaluations have failed to adequately consider the social implications which the community considers important. The study objectives include making a start at this important, under-researched subject.

1.2.4 National View

The study takes a national view which is in contrast with most technical studies in the past that have taken a single project approach or, at best, a regional approach. In taking a national view one must abandon the apparent great precision which has been a characteristic of many urban transport studies. To study the urban transport needs in a particular city, detailed inventories of facilities, origin-destination surveys, traffic counts, elaborate computer traffic forecasting and detailed financial and economic analysis of new facilities are appropriate.

To achieve a national perspective, however, within modest time and cost constraints, such apparent precision is impractical.

It is hoped that taking a national perspective will make the results more useful in the formulation of new research policies and programmes that may in due course achieve nation-wide, long-range efficiency improvements. The methods of dealing with national aggregates are discussed in Chapter 10.

1.2.5 Research

The project is primarily concerned with research priorities and policies. Implementation policies are not expected to emerge directly. Rather, this study is intended to provide provocative suggestions for further research and pilot projects which eventually will result in improved urban transport policies and efficiencies.

1.2.6 Bird's Eye View

One essential feature of the project is to maintain a very broad, bird's-eye view. It is suggested that progress on urban transport research can be made by successively taking bird's-eye and worm's-eye views of the transport problem. The bird's-eye view provides an overview or macro-examination of the total transport scene. It identifies those problem areas warranting the more detailed study, provided by the micro, or worm's-eye, viewpoint.

Successive iterations in the changes of viewpoint of study will lead to an improved understanding of the transport problem. On each iteration the improved worm's-eye views of parts of the whole will be used to improve the bird's-eye view; and the bird's-eye view will be used to identify the most important locations for improved worm's-eye views.

The thrust of this project has been to initiate this process by first constructing a broad overview of Canadian urban transport such that the priorities and cost effectiveness of urban transport research projects may be evaluated in the context of a complete urban transport picture.

It has only been possible to jump to this big view by using some very broad brush strokes and bold assumptions. Many of these assumptions are based upon slim evidence and substantial inputs of professional judgement. Some of these assumptions can quite properly be challenged. Indeed, further progress, of the iterative type described above, will most likely be made by the process of challenging such assumptions and then doing the necessary detailed work to confirm them or show the need for change. With the broad perspective acting as a frame of reference for such challenges and debate, it is hoped that the project will make a significant contribution to the ongoing task of making Canadian cities better for living.

1.3 WORK PROGRAMME

The work programme for the project during both phase 1 (contract of November '68) and phase 2 (contract of June '70) has been executed largely "in house" by N. D. Lea & Associates Ltd. During phase 1, the Steering Committee provided a useful source of ideas and an excellent panel for critical review. During phase 2, the interdepartmental committee provided some comments principally upon the technical memoranda.

During the first few months of the phase 1 project, a small team assimilated the current pertinent literature, constructed the logical skeleton of the project and established boundaries. The project was sub-divided into tasks which followed generally the table of contents of this report.

Selection and definition of the analytical methodology described in Chapters 7,8,9,10,11, and 12 was a major undertaking. During the latter few months of phase 1 the staff was increased to carry out the data gathering, processing and report writing.

Senior technical guidance for phase 1 of this project was provided by a Steering Committee consisting of senior personnel from both the consultant and the client plus the special consultants. The Committee met for the first time in Toronto on October 28, 1968, at which time the study began to take shape and direction. A second meeting was held in Toronto

on December 2, 1968, at which time the work outline for the study was reviewed and revised. A third meeting was held in Toronto on January 24, 1969, at which time the analysis procedures and approaches were reviewed and commented upon. During the data gathering and analysis phases, the members of the Committee kept in touch with the progress of the study. The draft report of July 1969 was reviewed and various points discussed in the final meeting in Toronto.

On October 30, 1969, senior staff from N. D. Lea & Associates Ltd. made a seminar-type presentation of preliminary study findings to a special meeting of the Federal Interdepartmental Committee on Urban Transportation.

The first step in phase 2 was the rewriting of the findings of the study in the form of a series of technical memoranda, each dealing with one category of possible action for efficiency improvement. This step also involved some more intensive technical studies, particularly of aspects such as pricing, which had not been dealt with in detail in phase 1. As the technical memoranda were prepared in draft, they were submitted to the Interdepartmental Committee for review and the informal comments of this committee were considered before finalizing the memoranda.

The second step in phase 2 was the complete editing and revision of the principal report, which is presented hereby. Chapters 1 to 14 are edited versions of parts of the draft report of July 1969. Chapters 15 to 24 are an abbreviated edition of the technical memoranda.

1.4 ACKNOWLEDGEMENTS

Appreciation is expressed for the assistance received from:

- Ministry of Transport
- Central Mortgage and Housing Corporation
- Canadian Transit Association
- Smith Transport Limited

Thanks are also tendered to the following consultants who provided specialized services during the study:

- Robert F. Baker, Transportation Research Consultant, Bethesda, Maryland.
- Hans Blumenfeld, Planning Consultant, Toronto, Ontario.

- Tillo E. Kuhn, Professor of Economics, York University and special consultant to N. D. Lea & Associates Ltd.
- Konrad Studnicki-Gizbert, Associate Professor of Economics, York University and special consultant to N. D. Lea & Associates Ltd.
- Britton Harris, Professor of City & Regional Planning, University of Pennsylvania, Philadelphia, Pa.
- Richard M. Soberman, Associate Professor of Civil Engineering, University of Toronto.

The members of the phase 1 Steering Committee were as follows: D. Scrafton, Ministry of Transport; G. Carruthers and later J. Fowlie, Central Mortgage and Housing Corporation; R.F. Baker, H. Blumenfeld, T. E. Kuhn and N. D. Lea (chairman).

The overall coordination for this project was by N. D. Lea as project principal. Mr. G.C. Harper was project engineer during phase 1 and Dr. R.S. Wallace during phase 2.

The analysis techniques and opinions contained in the report are the sole responsibility of the consultant and do not necessarily reflect either official or unofficial concurrence by the Ministry of Transport or any agency represented on the Interdepartmental Committee on Urban Transportation.

CHAPTER 2

URBAN CHANGE

To establish the Canadian urban setting, in which transport efficiency improvements are to be considered, this chapter describes, in Section 2.1 to 2.4, the four powerful forces producing rapid urban change, and then discusses, in Section 2.5, the strain producing impact of these changes upon the Canadian society. The following are the sectional headings:

2.1 POPULATION GROWTH

2.2 INCREASING URBANIZATION

2.3 INCREASING AFFLUENCE

2.4 GROWING CITY SIZE AND POPULATION

2.5 STRAINS OF CHANGE

- 2.5.1 Cultural Strain
- 2.5.2 Housing Effects
- 2.5.3 Transport Effects

2.1 POPULATION GROWTH

As shown in Figure 2f1, the population of Canada has been growing steadily for the past 70 years, at an annual compounded growth rate of about 2%. Although there have been fluctuations in this growth rate, the overall average has been maintained quite consistently. This trend is expected to continue for the forseeable future.

Advances in medical science have made a significant contribution to the population growth in Canada and in the world over the last hundred years. Since the introduction of oral contraceptives, in about 1960, there has been a decline in the birthrate in Canada, the United States and other developed parts of the world. Immigration remains a significant factor for Canada and tnus we have adopted, in this study, a population growth rate of 2% per annum between 1966 and 2001. This may be compared with the following population growth rates:

	Population Growth Rates % per annum	
	Actual 1965	Expected 1975
INDIA	2.4	2.1
WORLD	1.8	1.8
CANADA	1.8	1.9
WESTERN EUROPE	0.6	0.5

Source - Ref. (83), p.157

This force of growing population is one of the strongest pressures in the world and has been the subject of much discussion. Although it does not constitute a distressing problem for Canada, as it does for many other coutries, nevertheless, it is one of the major forces creating urban change in Canada.

FIGURE 2f1

POPULATION GROWTH IN CANADA

RURAL AND URBAN DISTRIBUTION

Source: Table 2t1

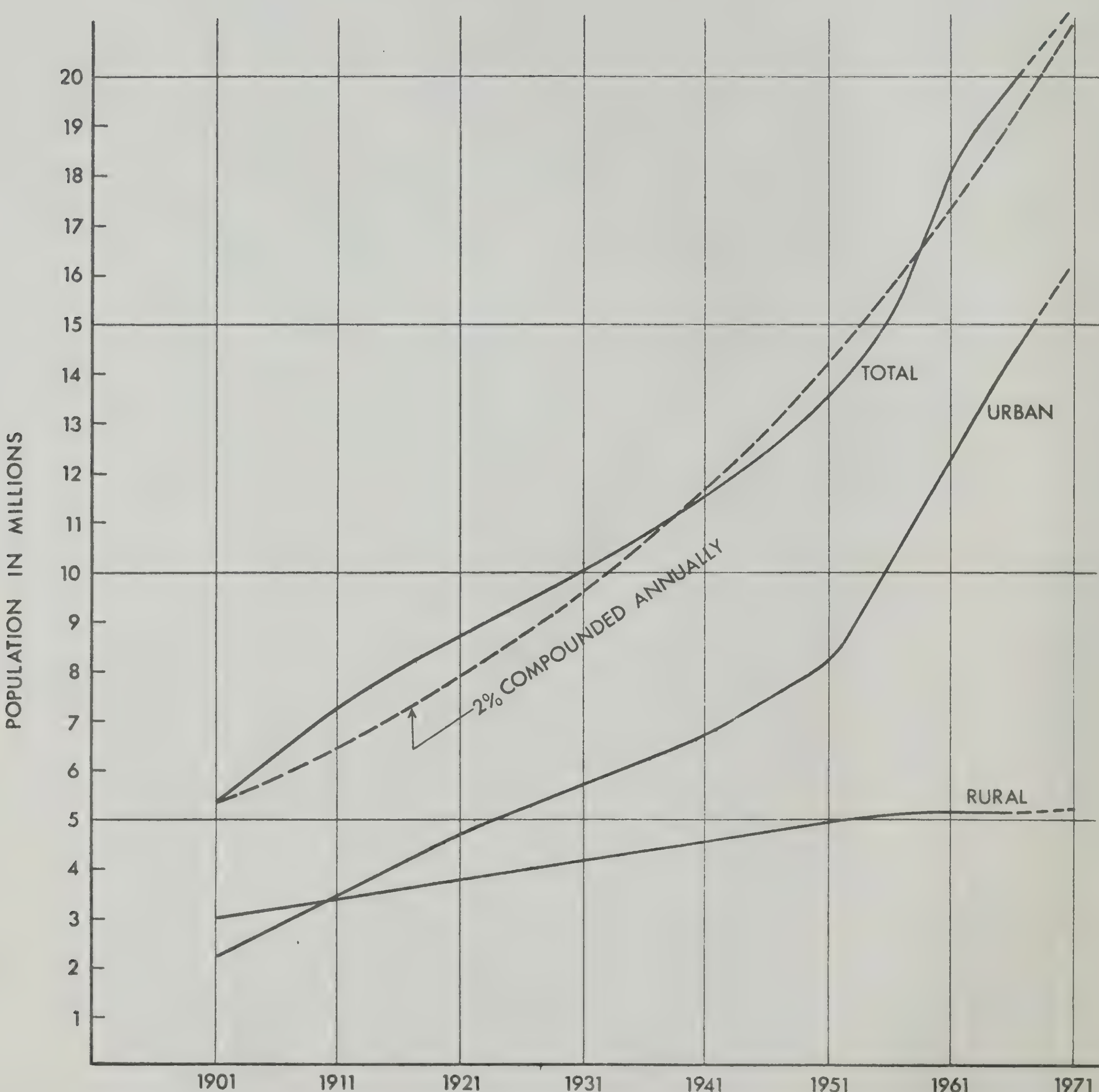

TABLE 2t1

GROWTH OF THE CANADIAN POPULATION

WITH RURAL AND URBAN DISTRIBUTION

Year	1901	1911	1921	1931	1941	1951	1961	1966
(1) Population in 000's								
Rural	3000	3600	4000	4300	4750	5190	5270	5290
Urban	2370	3610	4790	6080	6760	8460	12970	14730
Total	5370	7210	8790	10380	11510	13650	18240	20020
(2) % Growth (decennial)								
Rural	-	20%	11%	7%	10%	9%	2%	0%
Urban	-	52%	33%	27%	11%	25%	53%	13%
Total	-	34%	22%	18%	11%	19%	34%	20%
(3) % Distribution								
Rural	56%	50%	46%	42%	41%	38%	29%	26%
Urban	44%	50%	54%	58%	59%	62%	71%	74%

Note: DBS 1956 classification used as a basis of urban-rural distribution.

Source: DBS Ref. (29).

2.2 INCREASING URBANIZATION

Figure 2f1 and Table 2t1 show that, for the past century the Canadian urban population has been growing much more rapidly than the rural population. By about 1911, for the first time, urban population equalled the rural population. Around 1956, the urban population was double the rural population and, by 1967, the urban population was three times the rural population. The population forecasters are unanimous in their expectation that this trend will continue. At the end of the century, the urban population is likely to be five times the rural population.

This increasing urbanization is part of a world wide trend which began with the industrial revolution. Prior to 1800, cities over 100,000 persons consistently contained less than 3% of the total European population. * Since about 1800, the urban population of the world has steadily increased as a percentage of the total. This increased urbanization derives directly from technological advancement both on the farm and in the factory. The farms have become more efficient and the number of people who can be fed by one farmer has steadily increased. Similarly, other primary industries located in rural areas are steadily increasing their efficiency. At the same time, every increase in efficiency of rural industry is accompanied by an increased demand for the services and goods which are supplied primarily from urban areas.

2.3 INCREASING AFFLUENCE

Table 2t2 compares recent rates of growth of the Canadian GNP with those in other countries. When account is taken of Canada's higher population growth rate, it is seen that the growth rate of the Canadian per capita real income is about the same as that in the U.S., and that per capita income in many of the countries in the western world is growing more rapidly than in Canada. Also, some of the developing countries have started to have growth rates comparable to those in the developed countries. A continued growth, in real per capita income, of about 2% per annum to the end of the century is considered a reasonable expectation.

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* see references (44), (17), & (83)

TABLE 2t2

THE EXPANSION OF REAL G.N.P.

(1950-55; 1955-60; 1960-65)

Annual Average Percentage Rates of Increase

DEVELOPED COUNTRIES	1950-55	1955-60	1960-65
Canada	4.7	3.3	5.5
United States	4.3	2.2	4.5
France	4.3	4.6	5.1
Germany (F.R.)	9.3	6.3	4.8
Italy	6.0	5.5	5.1
Japan	12.1	9.7	9.6
United Kingdom	2.7	2.8	3.3
DEVELOPING COUNTRIES			
Argentina	n.a.	n.a.	2.0
Brazil	n.a.	n.a.	3.8
Columbia	n.a.	n.a.	4.5
Vanezuela	n.a.	n.a.	5.0
Greece	7.0	5.4	8.7
Spain	n.a.	4.3	9.2
Turkey	6.3	5.2	4.3

Source - Ref. (84) Table 4B

This rising per capita real income is a result of increased productivity due to improved technology and the use of more power per worker. The rising incomes require and produce more transport. In order to achieve increased productivity, goods are moved in greater quantity over greater distances. Because of the increased income, people choose to travel more for social and recreational purposes and many choose to live at lower densities in suburbia which substantially increases travel.

Increasing affluence is, therefore, a major force for urban change and it has a direct bearing upon urban transport.

2.4 GROWING CITY SIZE AND POPULATION

City growth is considered to be a force separate from urban and population growth because it is theoretically possible for the latter two to increase without changes in the average size of cities. Such a growth pattern would require that most population increases be in new cities. This is not at all what has been happening as is shown in Tables 2t3 and 2t4. From 1901 to 1966 the urban population of Canada increased from 44% to 74% of the total. During this period, Toronto and Montreal consistently contained 28% to 32% of the total Canadian urban population, while the 21 other cities of over 100,000 population in 1966, contained 34% to 40% of the urban population. These 23 cities have absorbed two thirds of the growth for the past 70 years. Indeed, they have in this period advanced from holding 62% of the urban population in 1901 to holding 67% in 1961. During the 20th century there have appeared in Canada about 170 "new cities", i.e., towns whose populations grew past 5,000 inhabitants; but not one of these "new cities" reached 100,000 by 1966. The "new cities", plus all other cities under 100,000 in 1966 accounted for less than one third of Canada's urban population growth in this century.

Large cities are a modern phenomenon. Before the scientific and industrial revolutions only a few unusual world cities, such as capitals of empires, exceeded 100,000 inhabitants. Before 1850 London was the only metropolitan area in the world which had exceeded one million in population. Between 1850 and 1900, three U.S. cities and 8 cities in other

parts of the world exceeded one million inhabitants. By 1960 there were approximately 141 cities in the world with a population in excess of one million including two in Canada: Montreal and Toronto. By 1960 three metropolitan areas exceeded ten million people: London, New York and Tokyo. *

This rapid growth of modern cities is directly related to the industrial and scientific revolutions. The engineering and scientific developments of the last 100 years have made the modern, large, low-density city possible. In particular, modern sanitary and transportation engineering developments are essential to support very large low-density cities with affluent living standards. As the technological advance continues, there is a very strong tendency for big modern cities to continue growing, both in population and in area. There is no indication of a slackening in this trend, even for metropolitan regions containing 10 to 15 million people. No Canadian city will reach this size before the mid-twenty-first century. Our big cities continue to expand in spite of the fact that many people consider very large cities unattractive and uneconomic.

The reasons for the continued growth of cities are not fully understood, but they certainly include the advance of human knowledge with the resulting specialization. Various investigations of the growth of scientific knowledge indicate a growth rate of about 5% per year compounded annually **. Using a technological index that considers power consumption, steel production, etc., Fisher calculates about a 4% growth rate for U.S. ***. A 5% annual growth rate is a doubling every 15 years. This rapid growth in knowledge, combined with the approximately constant capacity of the individual human brain, forces ever increasing specialization. This specialization, in turn, requires the geographic concentration of people in order to achieve population and employment pools of adequate size in each specialization. Both the employer and the employee profit from specialized labour pools of adequate size. The larger cities also give a greater variety of opportunities for education, recreation and culture, as well as for employment. They also permit manufacturers to build large plants with a substantial part of their market on short distribution lines, requiring no inter-city transport.

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* see Ref. 12
** see Ref. 13
*** see Ref. 45

TABLE 2t3

GROWTH OF SELECTED CANADIAN CITIES

(The following are all the cities and metropolitan areas in Canada with more than 100,000 people in 1966)

City	1901	1911	1921	1931	1941	1951	1961	1966
		Population over 1,000,000 in 1966 (in 000's)						
Montreal	413	613	791	1079	1207	1472	2111	2437
Toronto	263	440	646	859	957	1210	1825	2158
Subtotal	676	1053	1437	1938	2164	2682	3936	4595
% of Total Cdn. Pop.	13	15	16	19	19	20	21	23
% of Urban Pop	28	29	30	32	32	32	30	31
	Population between 100,000 and 999,999 in 1966 (in 000's)							
St. Johns Nfld	26	31	41	43	51	69	92	101
Halifax	51	58	75	79	99	134	184	198
Sydney-GIBay	25	50	62	68	81	100	109	106
St.John NB.	46	49	55	56	63	78	96	101
Chicoutimi-Jonquire	4	9	16	29	43	76	105	109
Quebec City	96	111	133	186	214	276	358	413
London	52	61	74	87	97	129	181	207
Kit.-Waterloo	38	46	59	73	83	107	155	192
Hamilton	83	117	160	197	215	280	395	449
Ottawa	94	123	160	190	228	292	430	495
Oshawa	7	10	16	28	33	50	81	100
Sudbury	4	10	16	28	45	74	111	117
St.Catharines	14	20	33	41	48	67	96	109
Windsor	17	24	52	87	119	164	193	212
Winnipeg	48	157	229	295	302	357	477	509
Regina	2	30	35	54	59	71	112	131
Saskatoon	1	12	26	43	43	53	96	116
Calgary	6	51	72	95	100	142	279	331
Edmonton	10	41	71	95	112	177	338	401
Victoria	40	57	64	70	86	113	154	173
Vancouver	59	175	224	338	394	562	790	892
Subtotal	718	1242	1673	2182	2515	3371	4832	5462
% of Total Cdn. Pop.	15	17	19	21	22	25	26	27
% of Total Urban Pop.	34	34	35	35	37	40	37	37

TABLE 2t4

GROWTH OF CANADIAN CITIES - SUMMARY TABLE

Category	1901	1911	1921	1931	1941	1951	1961	1966
For 23 Cities with Population over 100,000 in 1966								
Total Pop.000's	1394	2295	3110	4120	4679	6053	8768	10057
Average Pop. in 000's	64	100	135	179	203	263	381	435
% of Urban Pop.	62	64	65	68	69	72	67	68
Remainder of Urban Population (Cities and Towns with Pop. of 5000-99,999)								
Total Pop.000's	890	1315	1680	1960	2081	2407	4208	4673
% of Total Cdn. Pop.	16	18	19	19	18	17	23	24
% of Urban Pop.	38	36	35	32	31	28	33	32
Tot. Urban Pop. in 000's	2370	3610	4790	6080	6760	8460	12970	14730
% of Total Cdn. Pop.	44	50	54	58	59	62	71	74
Rural Pop. 000's	3000	3600	4000	4300	4750	5190	5270	5290
TOTAL CANADA in 000's	5370	7210	8790	10380	11510	13650	18240	20020

Source: D.B.S. Population ref. (41)

The dynamic population growth of the larger cities is usually accompanied by a decline in residential densities.* The combination of rapid population increase and declining residential densities, of course, results in a very dramatic growth in city area and a rapid rate of urbanization of land at the urban-rural fringe.

2.5 STRAIN OF CHANGE

Our cities are being strained under the great forces of change. The strain shows in changing social needs, housing needs and transport needs.

2.5.1 Cultural Strain

Although our society may give more rewards than a less developed and less technologically oriented society, it also places greater demands upon the individual. Low pressure jobs become more difficult to find. Because of the rapidly changing technology, re-training becomes necessary for more people during a normal lifetime. The mobility of our society produces high neighbourhood population turnover rates. These effects may contribute to the increasing crime and suicide rates. Our education, welfare, health and recreation systems are required to change at a very rapid rate. It, thereby, becomes very difficult for social service agencies to maintain quality and human interest. These cultural strains are not evaluated under this project.

2.5.2 Housing Effects

With growing population and growing affluence, the housing demands increase tremendously.

Rapid city growth creates a particularly serious problem for low income families. These families depend upon the stock of older housing for low cost accommodation. During periods of rapid growth, there is a comparatively smaller proportion of older housing available, and this shortage may be accentuated by the demolition of older housing to make way for new development.

Housing is not a direct concern of this project except insofar as it is inter-related with transport. Some interrelationship is evident in land prices, which are considered in Chapter 20.

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* see ref. (1) (11 city study) and Section 3.2 for discussions of preferred residential densities.

Also, since housing and transport are the two principal areas in which government can act to alleviate the strain of change, they may become competitive for funds.

There is one very significant difference between housing and transport. The transport system for any particular urban area is unmistakeably and unavoidably a "system". All parts, links and modes are vitally interconnected in geographic space such that a change in one aspect of one link has effects, throughout the system, on all other parts, links and modes. A transport system is something like a power distribution system. A change in the network which increases the total mileage of line may make the system work either better or worse depending upon the designers' understanding of the system. It is important to understand the system's effects before attempting to meet need by adding to the transport system. By contrast, housing has no substantial systems effect in itself. If the stock of a particular type of housing is short in an urban region, then the shortage may be satisfied simply by building more, any place within the region. No systems effects need be considered.

Housing and transport interact through linkages with private and government services (schools, stores, etc.). These interactions may be evaluated through a good transport systems model. For example education serves the population which is distributed according to the available housing stocks. It is the transport system which interconnects the educational and housing facilities. A transport model can thus be used to optimise the educational arrangements for a particular housing arrangement or vice-versa.

Therefore, if the transport effects are thoroughly understood and evaluated, the total effect of transport plus housing may be evaluated by modest adjustments to the transport evaluation system.

2.5.3 Transport Effects

The transport system of an urban area creates the accessibility matrix of the area. This matrix has a dynamic interrelationship with the spatial distribution of all activities within the area. The impact of city growth and increased affluence is very great upon the transport system. New transport systems also affect the character and shape of the urban area.

The nature of this interrelationship may be expressed in terms of the trade-off between living space and accessibility. * It may be described by suggesting that people prefer to live at a certain desirable dormitory density, and that they will adopt any means of transportation that makes this density possible, provided they can afford the out-of-pocket transport cost. This concept is developed further in Chapter 3 "A Transport Theory of Urban Change".

One of the transport effects resulting from urban growth and affluence is a deficiency of transport facilities and of adequate transport planning. The potential efficiency improvements identified in this study and discussed in Chapters 15 to 23 will, in the most part, be achieved by overcoming these deficiencies.

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* see Appendix A

CHAPTER 3

A TRANSPORT THEORY OF URBAN CHANGE

This chapter presents a theory explaining the transport - land-use inter-relationship. Such a theory is needed to improve the understanding of this relationship as a background for this project. It is presented under the following sectional headings:

3.1 SUMMARY THEORY STATEMENT

3.2 MOST DESIRABLE DENSITY

3.3 THEORETICAL CITIES

3.4 TORONTO - AN EXAMPLE

3.5 NEW YORK CITY - AN EXAMPLE

3.1 SUMMARY THEORY STATEMENT

It is postulated that:

ON THE AVERAGE, AN URBANIZED POPULATION PREFERS TO LIVE AT SOME DESIRED DENSITY 'D_O'. AT THE SAME TIME NO ONE WISHES TO LIVE MORE THAN 45 MINS. TRAVEL FROM THE C.B.D., THEREFORE, THE POPULATION WILL LIVE AT DENSITY 'D_O' UNLESS THEY ARE UNABLE TO DO SO BECAUSE:

- THEY ARE TOO POOR TO BE ABLE TO PAY THE TRAVEL COST ASSOCIATED WITH LOW DENSITY LIVING (POVERTY)
- IT IS NOT PRACTICAL TO ACHIEVE BOTH GOALS, (I.E. DENSITY 'D_O' AND 45 MINS.) BECAUSE OF THE TRAVEL SERVICE AVAILABLE
- REGULATIONS (ZONING OR OTHERWISE) REQUIRE DIFFERENT DENSITIES (DECREE), OR
- A COMBINATION OF THESE

3.2 MOST DESIRABLE DENSITY

People only express their individual density preferences in a direct way in their selection of housing. Herein, population density is defined as the total population divided by total land area. It is expressed as inhabitants per square mile. Even though only between 25% and 50%* of a city's total land area is in residential use, we still work with overall or gross residential density, rather than net, because the distinctions between various land uses are not sufficiently precise. For example, the distinction between residential land and public rights-of-way: large building set-back requirements and a wide street with no set-back requirements would be exactly the same in use but would show substantially different land use statistics. Similarly, the sum of neighbourhood recreational land and residential land is the more significant as a density consideration. Thus, in the absence of further needed research**, overall density, is the most useful at present. Certainly, in the N. D. Lea & Associates Ltd. study of 11 Canadian cities, it was only by using overall densities that consistant, meaningful results were obtained in making density comparisons between cities.

This theory only becomes tenable and useful if there is some evidence for a most desirable density D_O which is found to be reasonably constant.

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* See reference 37, Corridor Study, and particularly Technical Working Paper No. 1.

** Doxiadis in Ekistics p.129 recommends such research (75).

Studies of optimum density are rather scarce. There have been some studies which indicate that unless single family dwellings occupy lots of at least 0.3 acres the occupants feel the lots are too small(4). If everybody lived in single family dwellings on 0.3 acre lots, the overall population density, including public space and other uses, would be about 3,000 persons per square mile. Of course, everyone does not wish to live in single family dwellings. An average preferred density of 5,000 to 6,000 per square mile, is reported for the new suburbs of the New York urban area (5). Canadian cities seem to be tending toward a density of 6,000 to 7,000 per square mile (1&2). This information, scarce though it is, does give some indication of an optimum land density. All three sources are in reasonable agreement. Thus, 6,000 people per square mile might be taken as a reasonable estimate of the preferred Canadian density 'D_o'.

Possibly the preferred density varies to some degree with time. We have assumed no time dependency, to permit a logical analysis of the inter-relationship over time between city size, population density and transportation. Some rather scant historical evidence*, judgement and theoretical simplicity leads us to accept this assumption, at least for a trial of the theory.

3.3 THEORETICAL CITIES

The theory may be applied in an illustrative way by using a series of theoretical cities as is done in Table 3t1. This table assumes an ideal circular city with an average population density of 6,000 people per square mile. Each line on the table describes a transport system and the largest city which can employ the system and have the possibility of travel from the circumference of the city to the centre in 45 minutes.

Thus, for the city #1, which is served only by walking and horse-drawn omnibus with an average line speed of 4 miles per hour, the radius is only 3 miles, which gives a total area of 28 square miles and a population of 170,000 people. For city #1, the average cost to travel from any point in the city to the center is 7½¢ and the average time for that trip is 32 minutes.

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* See Doxiadis "Man's Movement and his Settlements", Ekistics May 1970 p. 296 (85).

TABLE 3t1

INTER-RELATION BETWEEN CITY SIZE, POPULATION DENSITY, AND TRANSPORTATION

Theoretical City No.	Transportation Mode	For 45 min.trip from centre to circumference (1)				For an Average CBD Work Trip			
						Cost in 1968 prices excluding travellers time (cents)			
		Line Speed (mph) (2)	City Radius (miles)	City Area (sq.mi.)	City Population at average density of 6000/sq.mi. (Millions)	Perceived or Marginal (3)	Total (4)	Door to Door Trip Time (Min.)	Door to Door Speed (mph)
1	Walking	4	3	30	0.2	0	7	32	4
2	Street Car or Motor Bus	10	6	100	0.6	25	27	39	7
3	Automobile on Grade Streets	17	11	400	2.4	56	91	33	16
4	Subways with Surface Transit Feeders	25	11	400	2.4	32	42	39	13
5	Commuter Trains	35	13	500	3.0	52	82	39	17
6	Autos on Freeways: Med.Level of Serv.	35	18	1000	6.0	86	145	36	27
7	Autos on Freeways: High " " "	50	25	2000	12.0	122	196	36	37
8	Mini-Transit or Automated taxi-Transit or Personal-ized Transit (Programmed Module)	45	25	2000	12.0	144	146	36	32
9	Automated Ways	70	35	4000	25.0	224	327	36	50
10	Automated Ways	100	55	9000	55.0	552	719	36	69

(1) It is this trip time which determines the radius of all cities on this table.
(2) The line speed shown is the average speed from boarding to debarking the vehicle on the principal mode.
(3) Cost as perceived by traveller, e.g. subway fare or out of pocket auto costs.
(4) Total cost, e.g. actual cost of moving subway passengers or total auto cost, including depreciation.

Table 3t1 shows that the size and population of these theoretical cites, and also the cost of transport, gradually increase with improved modes of transport. The largest is City No. 10 with automated ways at a line speed of 100 miles per hour (average speed 69 mph), a radius of 55 miles, an area of 9,000 square miles and a population of 55 million people, all living at an average density of 6,000 people per square mile. The average travel time to the center is only 36 minutes but the cost of an average trip is over $7.

No suggestion is made that any of the theoretical cities shown in Table 3t1 have ever been built or ever will be built, but consideration of these theoretical cities does help in understanding what has been happening, and what is happening, to real cities.

3.4 TORONTO - AN EXAMPLE

For example, consider the city of Toronto. Toronto was a well established compact urban area before the era of the motor car. By 1920, which was the heyday of the street car, there were over 600,000 people in metropolitan Toronto. The core, which now has over 20,000 people per square mile, was developed during the street car dominant period. The total area of the city by the end of this period, in about 1920, was about 32¼ square miles (74). Toronto of 1920 may be compared with theoretical city number 2. Because Toronto is approximately a half circle instead of a whole circle, one would expect that some 300,000 people would be the maximum that could be serviced by street car, at the optimum density of 6,000 people per square mile. Therefore, in order to accomodate 600,000 inhabitants without going beyond a travel time of 45 minutes from the center, the density had to double to about 12,000 people per square mile. In fact, the density was somewhat greater than that and Toronto in 1920 was somewhat smaller than suggested by theoretical city #2. The smaller size may have been due to the fact that the income of the people was not high enough to permit them to travel the distances necessary to live at lower densities.

With the advent of the motor car, the area around Toronto rapidly developed as a low density suburbia. Following the retarding effects of the depression and the Second World War, this expansion took place with explosive force. From 1945 to 1968 Toronto suburbia has been expanding rapidly and the growth has been through new land development at a uniform low density. Therefore, the overall density of the urbanized Toronto metro area has been steadily declining. It declined from about 12,500 people per square mile in 1941 to about 8,200 people per square mile in 1961. By 1966 the urbanized Toronto region occupied about 220 square miles and contained about 2.1 million people. If this is doubled to 4.2 million people for comparison with a theoretical circular city, i.e. #3, #4, #5, #6 and #7, it will be observed that Toronto has grown beyond the size that can be adequately served by automobiles-on-grade-streets and subways, but that there is still ample room for development which is dependent on service by freeways and commuter trains. This explains why the new low density suburban developments are all auto-oriented and why pressure has developed for some new types of transit, such as the GO-transit railway commuter line.

It is interesting to note that the density of the City of Toronto, the inner core city, has not declined, but has remained more or less constant over the last twenty years (1). The cause appears to be income distribution. There remains a large group of people in Toronto who live in rather crowded sub-standard inner city housing, and who are not able to afford the more expensive low density suburban living.

This theory, although a great over-simplification (it ignores, for example, high quality, high density housing), nevertheless, gives a reasonable and comprehensive understanding of the basic phenomenon.

Applying the same theory, Montreal, with a per capital income of $2,050 in 1965, is seen to suffer from more crowding than does Toronto, with a per capita income of $2,590 (1) and thus, at present, Montreal has the highest density in its downtown core of any city in Canada.

3.5 NEW YORK CITY - AN EXAMPLE

The New York metropolitan region may also be used as an interesting example of the inter-relationship between city size, population density and transportation.

In 1860 the urbanized parts of New York contained two million people, in an area of about 30 square miles, thus resulting in an average density of 65,000 persons per square mile*. The area of New York at that time and the method of transportation were similar to theoretical city #1, in Table 3t1. In order to get all of the people into the restricted area which could be serviced by transportation, the density was 10 times the optimum density. By 1900, the population of the urbanized region, now 140 square miles, had risen to more than 5½ million, but suburban development and the introduction of the electric street car in the 1880s and the elevated and suburban steam railways permitted the overall urbanized density to drop to 40,000 persons per square mile*. The area of Manhattan (approximately 31 square miles) is about as large as can be served by street cars without getting travel times much over 45 minutes. This became an increasingly severe restriction and thus Manhattan density began to rise again, until about 1910, at which time Manhattan was practically fully built up with an average density of over 100,000 persons per square mile and with some parts having a density of half a million per square mile (12). In the 20 years between 1910 and 1930, as a result of smaller families living downtown, and of the subway system which permitted people to live off the island, the Manhattan density dropped to an average of about 77,000 persons per square mile.

Since 1940, development has been repid on the outskirts of the New York metro region. Between 1940 and 1954 each additional million of population was accompanied by the urbanization of 185 square miles of land - 5400 inhabitants per square mile*. Thus, the result of mushrooming motor vehicle travel has been rapid suburban expansion. The core population and employment has been declining slightly and is forecasted to do so in the future as shown in Table 3t2:

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* see reference (5) p.273

TABLE 3t2

Population and Employment - New York Metropolitan Region

	New York County (Manhattan)	Central Core Counties	Metro Region
Population (000s)			
1950	1,960	8,348	12,500
1960	1,698	8.171	13,951
1975 (projected)	1,525	7,860	19,700
1985 (projected)	1,475	7,740	22,170
Employment (000s)			
1950	2,380 CBD*	3,900	6,403
1956	2,140 CBD*	3,900	6,403
1985	essentially unchanged	4,200	8,846

Source - Ref. (5)

* CBD - Central Business District

New York appears to have experienced overcrowding throughout its history because it has consistently been larger than the maximum city which can be served satisfactorily with the available technology.

Central Calcutta, by contrast, where good public transportation is not provided, is an example of overcrowded conditions because of poverty. At present Calcutta cannot afford the available transportation systems which would allow it to be spread out.

CHAPTER 4

CHARACTER OF URBAN TRANSPORT

This chapter seeks to give a better understanding of urban transport, firstly by viewing it in relation to other parts of the urban economy and secondly, by dissecting urban transport in various ways. The following section headings are employed:

4.1 MAGNITUDE OF THE TRANSPORT SECTOR

The urban system is a complex modern mechanism and a most important element in modern civilization. Transport plays a key role in the system.

Some concept of the magnitude of the role of urban transport may be gained from 4t1 and 4t2 which show transport in the context of a personal budget and of a municipal budget. It will be observed that urban transport, directly and indirectly, consumes some 25% of total personal expenditures and 18% of municipal government expenditures.

The effect of government transport expenditures, however, is much greater than suggested by their magnitude. For all other land services (sewer, water, gas, electricity, etc.) governments, including public utilities, spend practically all of the approximately $85/cap/year of total cost. Similarly, for people services (health, education, social, welfare, etc.), government spends most of the $175/cap/year. For urban transport, however, with only about $50/cap/year of direct expense*, the government exerts a major influence over total transportation expenditures of some $500/cap/year. It is this leverage which suggests the possibility of substantial government influence upon the achievement of basic goals through a comparatively modest transport expenditure.

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* Table 4t1 shows about $30 of direct municipal public works expense to which must be added the direct expenses of senior government less intergovernment payments. Using Ref. 76 we estimate the total at about $50.

TABLE 4t1

EXPENDITURE OF MUNICIPAL GOVERNMENT IN ONTARIO (1965)

	Total Gross $ mil. *	Per Capita $	Estimated Transport Component $ per cap.
General Government	83.5	15	1
Protection of personal property (fire, police, street lights)	154.5	28	4
Public Works	330.0	59	30
Sanitation & waste removal	112.1	20	10
Health	36.3	6	
Social Welfare	69.4	12	2
Education	482.9	86	
Recreation and Community services	57.4	10	-
Other	52.0	9	-
Debt charges	100.7	18	-
TOTAL	1,478.8	263	47

* Source: Municipal Government Finance (Revenue and Expenditures), 1965, D.B.S. Catalogue No. 68-204, Ref. (81).

TABLE 4t2

BREAKDOWN OF PERSONAL URBAN EXPENDITURE
(1966 - Canadian Representative City)

	$ Per Capita		
TRANSPORTATION			
Direct Personal Expenditure		235	
- auto purchase	100		
- auto operating	110		
- urban transit	10		
- other (taxis, rentals)	5		
- inter-city travel	10		
Indirect Expenditures		210	
- movement of goods	170		
- service vehicles other than government (telephone, repair services, hydro)	40		
Indirect		47	
- estimated portion of property & personal taxes	47		492
FOOD *			310
SHELTER *			
- rents, taxes, mortgages, repairs (excluding taxes for education)	200		
- public utility land services, including water, gas, electricity	50		
- other land services, including sewer, sanitation, fire, police, etc.	25		
- household operations (telephone, fuel,etc.	35		310
PERSONAL EXPENDITURE *			
- clothing and personal furnishings	135		
- household goods and furnishings	100		
- tobacco and alcoholic beverages	83		318
PERSONAL SERVICES			
- health and medical	70		
- education (including portion of property and personal taxes)	105		
- personal care, recreation	110		285
MISCELLANEOUS			
- personal taxes (excluding education), gifts, miscellaneous			335
GRAND TOTAL			2,050

* excluding our estimate of the transport component.
Source: Ref.(18) Urban Family Expenditures, 1964 and National Accounts, Income & Expenditures, 1966, DBS Cat.No.62-527 and 13-201.

4.2 SUBDIVISIONS OF TRANSPORT

The subject of urban transportation is such a large one that it needs to be sub-divided for study purposes. The way this sub-division takes place is very important because of its bearing upon the conclusions. One deficiency of some past approaches to urban transportation has been that one sector (such as CBD people travel) has been considered intensively, and others (such as goods movement) largely ignored.

Our principal division of urban transport is into three main sectors, namely:

- the transport of people
- the transport of goods
- service travel

The distinction between these three major sectors of transport is in what is transported. It may be people, or goods, or service personnel travelling with equipment to render the service (a plumber for example).

No precise estimates are available concerning the exact relative importance of the three major sectors of urban transport in Canada. From representative traffic counts and costing work which is part of this project, the total urban transport cost has been sub-divided approximately as follows:

- transport of people	- 50%
- transport of goods	- 40%
- service travel	- 10%
Total	100%

This crude cost breakdown does not necessarily indicate the relative importance of each sector. In terms of vehicle flows in the peak hour, people are much more important than goods. People, however, have several modes open as options: walking, public transit and auto, and there is also the possibility of communications substitution. There are fewer options for goods movement. At present, there is practically no substitute for the truck as an urban goods vehicle.

Person transport has usually been given priority because of the peak hour design importance and because of the direct personal involvement of so many citizens.

There has been considerable discussion of the substitution of information transmission for the movement of people. Present indications, however, are that in the forseeable future this will not occur to any significant degree. The volume of use of new communications facilities is increasing tremendously and the pace of business thereby increases, resulting in an increase in productivity and possibly even an increase in travel as well. Further improvements in information transmission may increase the possible amount of work done at home instead of in offices. This could have some effect, particularly on the peaking of the work trips. Such a shift appears unlikely to be a substantial factor in the near future. There is also the possibility of substituting communications and delivery service for shopping trips. This also does not appear a major factor. Therefore, non-transport substitution possibilities do not materially lessen the importance of person travel. Transport modal substitution possibilities, however, are real and significant and make person travel less critical. New York City could survive a strike of all transit operators but it could not survive a strike of all truck drivers.

There are a number of possibilities of substitution of goods so as to vary the transport demand. For example in the supply and distribution of power, there is a trend to reduce the requirement for motor vehicle transportation. Electrical power is distributed by transmission line and natural gas by pipeline. Because these enjoy lower distribution costs in some cases, there is a tendency to substitute them for coal, fuel oil and gasoline. The latter are the sources of power that require motor vehicle transport and, thereby, experience a higher cost of distribution. This is not a major factor, but for completeness in calculating transportation costs, electrical power distribution costs and natural gas distribution costs by pipeline might well be included.

There are also some possibilities of replacing truck transport by other modes for special commodities.

Pipeline distribution has been substituted for vehicular distribution of water, and sewers for the vehicular collection of night soil. Pipelines are sometimes used for transporting chemicals and petroleum products, and their use for transporting solids is increasing. These are largely industrial or intercity applications. The only significant major urban application is a potential one for garbage and ash removal. This is far enough in the future and sufficiently small not to affect this study significantly.

In general, truck transport is quite resistant to substitution, even though there are some possibilities which need to be kept clearly in mind, particularly in the development of new modes.

Service transport is the most resistant to substitution of any type and, therefore, it deserves special treament as it is given in Section 4.5

4.3 PERSON TRANSPORT

Person travel may be further subdivided:
- by mode
- by income
- by driving ability
- by trip purpose and
- by time categories

4.3.1 By Mode

Person trips may be classified by mode of travel as follows:

Personalized

Automobile

Automobile is the dominant mode, but vehicle occupancy has gradually been declining. This change is important, due to the street space requirements and costs involved. The marginal costs of a car pool operation, for example, are very low indeed. Where it is convenient for workers to use a car pool, it is not possible for any mode of transit to compete on the basis of cost or on the basis of service.

Taxi

Taxis are usually not analyzed separately in transportation studies, but they are a significant mode, particularly in the downtown sections of larger cities.

Mass

Bus

Bus operations are susceptible to statistical analyses and have been the subject of many urban transport studies.

Subways and Commuter Trains

Subways and commuter trains are also the subject of conventional transport analyses.

Private and Public Transport

Traditionally, considerable emphasis has been placed on the distinction between private and public transport, with the automobile being the example of private transport and the bus or subway the example of public transport. Two separate transport categories are mixed together, however, in this distinction. One should distinguish primarily between personalized and mass transport. The public vs. private distinction is of less consequence and is seldom carried through completely. For example, government autos are not private transport and a privately owned bus company may provide a public service in the same way that a taxi company also provides a public service.

Personalized transport often gives a much higher standard of service than does mass transport and is practically always preferred by the consumer. Users are willing to pay a large premium for it. There is no reason, however, why personalized transport should always be private and mass transport always be public. There are many examples of private mass transport systems and we may well, in the future, see public personalized transport systems.

4.3.2 By Income

For many purposes it is not acceptable to use only average income in the analysis of people's transportation. The low income sections of society in particular can experience hardships because they are unable to pay for transportation essential to their work and income. A breakdown of the population by income sector for transport analysis purposes is needed.

4.3.3 By Driving Ability

The following three categories are suggested to classify the population by driving ability:

Skilled Auto Drivers - Class A

These would be the people who, through their maturity, training, knowledge and skill, are competent as drivers of motor vehicles at high speeds on freeways and also onto and off guideways. Quite possibly the major correctable reason for the high traffic accident rates at the present time is the dangerous driver. He should not be permitted to drive. This fact is becoming recognized and one may expect a tightening of regulations, particularly as speeds increase. At present in Canada approximately one third of the population has motor vehicle operator licenses. If a stricter policy were adopted, one might expect that this percentage would not increase even though the car ownership continues to increase.

Class B Drivers

At the present time no distinction is made in the classification of drivers. If a person has a license he may operate any kind of motor vehicle at any posted speed on any road. No proof of skill or knowledge is required to operated a bicycle, boat, golf cart, snowmobile, or farm tractor. With the development of new technology, and the possibility of city cars with slower operating speeds, perhaps electrically powered, there may be good reasons for having two classes of drivers. Older people and some younger people would be unable, because of either age or infirmity, to obtain a Class A drivers

license. They could be issued, however, a Class B license, which would permit them to operate Class B vehicles at lower speeds, on specific routes.

Non-Drivers - Class C

There is, and will remain, a class of people who will not and should not travel alone. Apart from the obvious examples of babies in arms and stretcher cases, a significant part of the population requires that some other person accompany them for a trip of any length.

The significant question which is not yet answered, and which is an appropriate subject for further attention, is whether there need be a gap between Class B and Class C. Might it be possible to develop a Class B vehicle which can safely be operated by all the population who can and should travel on their own?

A very preliminary estimate indicates that approximately one third of the population is and will remain in the C category and about the same proportion might be in the B category.

4.3.4 By Trip Purpose

Table 4t3 gives an indication of the breakdown of person trips by trip purpose. Such data is usually obtained in urban origin-destination surveys for transport planning, so that a great deal of such information is available. Each category has some distinctive features, as discussed in the following paragraphs.

TABLE 4t3

PERSON TRAVEL BY TRIP PURPOSE

PERCENTAGE OF TOTAL PERSON TRIPS

From a small selection of home interview O.D. Surveys.

TRIP PURPOSE	Chicago 1956	Pittsburgh	Hamilton 1961
Home Based			
Work	32.5	32.8	36.3
Personal Business	14.5	18.8	in "Other"
Shopping	8.4	13.0	18.9
Education	3.4	10.5	in "Other"
Social/Recreation	19.8	12.0	20.5
Other (including non home based)	21.4	12.9	24.3

Work Trips

The largest single purpose category of person travel is "work". Work trips also show the greatest peaking in the morning and the evening rush hours and, therefore, create the critical design volumes for facilities. Work trips are indeed a very important part of urban travel and have properly received a great deal of attention in urban transport studies. Because these trips dominate in the peak hour, they establish the design requirements and thereby have been the greatest factor influencing the capital cost of most urban transport facilities. The time spent in most work trips is probably wasted. Travellers show a very substantial preference for rides that increase comfort by making the time productive for reading, socializing or other purposes. For example, travellers are willing to pay an increased fare for a guaranteed seat.

Personal Business Trips

Personal business trips are those with home as one trip end and with personal business, such as banking, paying bills and visiting the post office as the other.

Shopping Trips

Shopping trips display a number of distinctive characteristics. For example, the substitution of package delivery for some shopping trips is possible. One of the best examples is the choice between milk delivery and a shopping trip for milk. Also characteristic of shopping trips by auto is that the perceived cost is usually very low. Probably in no instance is the driver aware of a perceived cost more than the out-of-pocket expenses for gasoline and parking. Time is often not considered to be of significant value. The willingness of shoppers to spend a great deal of extra time in order to make small savings in the price of purchased articles suggests that they place quite a low valuation on their shopping time, or that the pleasure of shopping justifies the time spent.

Education Trips

Education is accounting for an increasing proportion of total trips. If the trend continues toward larger schools and more adult education, combined with low density residential living, then there will be an increasing proportion of young people who will not be able to walk to school and who will need some type of conveyance. This would result in a substantially increased urban transportation cost that is directly attributable to the form of the educational system. Therefore, the transportation effects of the school layout should probably be evaluated as part of the cost of the educational system.

Social-Recreational Trips

Social-recreational trips are steadily growing in importance. For an increasing part of the road system, the peak demands are being placed by social-recrational trips, rather than by work trips. Since these trips are growing more rapidly than work trips, we may expect in the future, that they will become increasingly important as the determinants of the layout of the transport system.

4.3.5 By Time Categories

One of the major issues in urban transport analysis is the way to treat the time of the users of the transport facilities and, in particular, the value which is to be

placed upon this time. Such an analysis would be made more useful if time were divided into the following categories.

Emergency Time
The highest value for transport time is for the occupants of emergency vehicles, such as ambulances, fire engines, police cars.

Paid Time
Many of the people travelling in any city are employees travelling on company business. The time spent in travel is fully compensated to them at their standard rate of pay, which is the price of this time. Any saving in this time can be a direct improvement in the efficiency of industry and of the urban region.

Unpaid and Wasted Time
The subway traveller who is packed into a subway car usually is not paid for the time, and he is forced to waste this time in an unpleasant, uncomfortable position. He is willing to pay something to reduce the length of travel time, but the amount which he is willing to pay may not be as great as his normal rate of compensation. Some studies indicate that it is in the order of half this rate.*

Unpaid But Useful Time
If the traveller is given more space and is made more comfortable, then he is able to make some use of unavoidable travel time. He is then less willing to pay to avoid spending this time in travel, but the amount by which he is willing to reduce this price depends upon his evaluation of the degree of usefulness of the activity which he can carry out during the trip. This degree of usefulness may be expressed as the degree of comfort and convenience.

Fun Time
Some people, at some times, travel purely for the fun or enjoyment of the trip. The roller coaster ride is one example, another is the Sunday afternoon automobile drive. Much of the driving by teenagers is of this type. Savings or reductions in this fun time are not benefits or improvements in real income. Why, then, do some people travel at high

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* Recently D.G. Tipping has criticized the usual approach to time saving evaluation (70) but no constructive alternatives have been produced.

speeds when out for enjoyment? It seems that some drivers travel at high speeds, not to save time but for the pleasure of speed itself. Similarly, the slower speed is not usually to consume more time, but rather to enhance the enjoyment of the drive.

4.4 GOODS TRANSPORT

Practically all goods transport in urban areas, except those which are carried by pipeline, are moved by truck. This motor vehicle dominance of goods transport establishes road transport as the most indispensable method of urban transport. The combined use of roads for both goods movement and people movement leads to high efficiency. Although person movement has been studied very thoroughly from the broad urban perspective, there have been very few city-wide studies of truck movements. A proper sub-division of this analysis by the various types of goods movement is almost non-existent. This is an area in which we shall attempt to break some new ground and make some recommendations for further work. Table 4t4 gives a suggested classification by type of service.

Pick-Up and Delivery Service
This is one distinctive type of urban trucking which has very high unit costs associated with it, because of the times consumed by pick-ups, deliveries and delays, and because the average load on the vehicle at any time is comparatively small. This category includes department store vehicles, parcel P & D operations and the postal service.

Bulk Haulage
Specially designed trucks are used for bulk haulage. These include dump trucks for granular material.

Special
An increasing amount of urban goods movement is by special vehicles, designed for a particular product such as cement trucks, concrete trucks, oil trucks, etc.

Service
The service vehicle is included here only for completeness because it is considered as a separate category under Section 4.5.

General Cartage
General cartage is used to refer to non-bulk goods, which are transported usually in an unpackaged state.

TABLE 4t4

URBAN TRUCKING

Classified by type of service
and type of carrier

TYPE OF SERVICE	TYPE OF CARRIER		
		FOR HIRE	
	PRIVATE	COMMON	CONTRACT
1. Pick-up-and-Delivery (packaged goods)	X	X	
2. Bulk Haulage earth, sand & gravel, snow, etc.	X		X
3. Single Product Special Vehicle fuel, cement, chemicals, concrete	X		X
4. Service Vehicles Fire, repair	X		
5. General Cartage Manufactured goods, semi-finished & wholesale (incl. food & construction)	X	X	X
Farm produce	X		
Moving machinery, furniture, etc.	X	X	
6. Containers		X	
7. Autos used for Pick-up-and-delivery	X		
8. Trucks as pure people movers	X		

X indicates the type of carrier which performs a substantial part of the indicated service type.

Containers

Containers are considered as a special item, although their volume is still comparatively small in urban trucking.

Autos as Goods Movers

Many shopping trips and much usage of station wagons is for moving goods and might be substituted by pick-up-and-delivery service.

Trucks as People Movers

Trucks are sometimes used just to move people. It may be 2 or 3 people in the cab of a pickup or it may be a larger vehicle with some type of benches, army style. Such transport, of course, should be treated as people movement not goods movement, but it is included here so it will not be overlooked.

One significant change which is taking place in urban trucking is the gradual increase in vehicle size. This creates problems, particularly in the downtown section of the city, even through most truckers use different types of vehicles for downtown and for the outskirts. The vehicle size constraint plus downtown congestion means that truck costs in the suburbs are generally much lower than in the downtown area.

In general, urban trucking is highly cost sensitive and should be capable of rigorous economic analysis. Surprisingly few economic analyses have been carried out on urban trucking. A small number have been done by the trucking industry itself but very little knowledge has been applied to urban transport planning studies.

This is an area of great potential for further research. The conference held in December 1970 as this report was being finalized, and sponsored jointly by the Canadian Ministry of Transport and the U.S. Department of Transportation is an encouraging sign that action is to be expected to fill this research gap.*

* See the conference proceedings and some of the more significant publications either presented at or referred to during the conference - references numbers 77, 78, 89 and 80.

4.5 SERVICE TRANSPORT

The distinctive feature of service transport is that it is essential that at least one person with a special skill be transported in the same vehicle as some commodities. He is commonly the driver of the vehicle. Telephone and hydro repair trucks are good examples of such service travel. For urban transport, service travel is exclusively by motor vehicle. It is difficult to imagine any other mode which could substitute. In rare instances a helicopter might be a substitute, or, in the future, some new mode of travel. Service travel has not usually been considered as a separate transport segment in urban areas. The separation of service travel may be important because of several special features connected with some of its requirements.

4.5.1 Emergency Services

Emergency services include police vehicles, fire trucks and ambulances. The very high value which is placed upon the time of these vehicles by the community is shown by the laws governing the use of sirens.

Emergency services represent a very small percentage of total urban transport. Approximately 1% of urban vehicles are for emergency services. The important service which these vehicles perform, however, merits study and analysis on their own.

The average time required for an emergency vehicle to get to the scene of the emergency is usually quite short. In Washington, the average travel time for an ambulance to reach an accident is 7 to 10 minutes. Some limited data, however, show that in a small percentage of the instances, the time increases to an unreasonably high figure (up to 60 to 80 minutes for ambulances), largely as a result of traffic congestion. A supplementary study is desirable to get more assessment of the seriousness of this problem. If sufficiently severe, there are several solutions which might be considered. Helicopter service might be used, or special ramps by-passing congested areas may be constructed for the exclusive use of emergency vehicles. In Moscow some centre strips are reserved for this purpose.

4.6 OTHER USES OF TRANSPORT FACILITIES

4.6.1 Military and Disaster Services

Military and disaster services are the responsibility of the Canadian Emergency Measures Organization. In order to explore the importance of military and disaster services it would be necessary to review this subject with the Emergency Measures Organization which has not been done as a part of this project. Generally speaking, it is considered that the possibility of a disaster is sufficiently small that large sums of money to prepare for it are not justified. EMO efforts have been concentrated upon special training, with some attention being given to the development of, and assigning of, emergency evacuation routes. If the EMO could define the requirements for such evacuation routes, it would be possible to rationaly modify urban transportation systems, using a modification of normal design techniques. Another flow analysis would be prepared to identify evacuation problems. Minor changes might be proposed in the physical facilities, in signing, and in the instruction of EMO staff. If such a procedure is considered of sufficient importance by EMO, the federal government could usefully deal with the issue through preparation of planning instructions, and perhaps some financial participation.

4.6.2 Celebrations and Demonstrations

Streets can be used for parades, celebrations and other demonstrations. Parks and pedestrian plazas can also serve to some extent for such purposes. At present, this issue does not require any special attention. However, if any major transport change were considered that might greatly reduce the number of motor vehicles, then the requirements of these functions may become more important.

CHAPTER 5

URBAN TRANSPORT ADMINISTRATION

This chapter describes the interlocking multi-leveled administrative structure which is involved with transport. Some of the administrative problems are discussed and the national consequences presented. The following are the sectional headings:

5.1 AREAS OF JURISDICTION

The physical and technological problems of changing urban transportation systems are accentuated by concurrent management problems. It is exceedingly difficult for community management and control processes to respond quickly enough to changing transport requirements. In most Canadian cities, as urban growth has taken place, the urbanized fringe has rapidly passed over municipal boundaries. Abutting municipalities become one unit as far as transport operations are concerned. Municipal boundaries become arbitrary and this creates serious problems in transportation planning, which logically should disregard arbitrary municipal boundaries. Even metro regions with aggressive annexation or amalgamation or metro government policies have had difficulty in keeping the metro area jurisdictional boundaries expanding as rapidly as urbanization takes place. Because of the tendency of urbanization to overflow municipal boundaries, one of the proposals coming from the February 1969 Urban Transportation Conference was for more regional or metropolitan government. It is highly desirable from a transport planning viewpoint that metro government have a sufficiently large area of jurisdiction to be able to coordinate and manage the total transport system in the whole urbanized region. Transport problems will still exist in the perfect administrative system, but there is some indication that the trend to regional government will assist urban transport planning and operation.

5.2 TIME HORIZON

Another major problem in planning urban transportation is that the necessary planning horizon is very much longer than government's term of office. For any major transportation project the time between conception and operation may be five to ten years or more. For any comprehensive transport planning it is necessary to look ahead at least ten years and preferably 20 or 30 years, because the useful life of the facilities is at least 10 to 20 years. Many governments have a term of office of only one or two years, and, at the most, the term of office may be four years. To give adequate consideration to planning matters that require a forward view of ten to thirty years and which, even under the best circumstances, cannot show material benefits in less than five years, is a very difficult task for a government that has a short term of office.

5.3 CO-ORDINATION BETWEEN MODES

As the number of modes of transportation within an urban area increases, the importance of establishing effective coordination between the planning of the several modes increases. With only one mode, there is very little problem. But as soon as there are two modes, such as roads and subways, for example, the coordination becomes important. As the number of modes increase the coordination increases in importance. This will become a very serious and important problem as new technology produces new modes, and these developments may not be far off. In many instances in Canada there is no required coordination between existing urban transport modes. Often, the financing is quite independent. There is an increasing demand for the establishment of area transportation authorities, each exercising planning and management control over all modes of transportation within a particular urban area.

5.4 FINANCE

Road transport experiences particularly difficult problems of finance. There are usually several levels of government directly involved in the financing of the roads. But an even more troublesome division is between private financing of motor vehicles and public financing of roads. With this wide difference in source of financing of the two component parts of a road transport system, it is very difficult to achieve the rational financing programme such as is achieved, for example, on a railway where the rolling stock and roadbed are administered by the same management. On the one hand, we find motor vehicle owners freely spending on average 12¢ per vehicle mile in total operating costs. On the other hand, modest road costs, in the order of 1¢ per equivalent vehicle mile for construction and maintenance, are allocated sparingly by the responsible public authorities because these road building and maintenance authorities are subject to much different budget criteria than the private user. The result is that in many instances motor vehicle users are prohibited from making the adequate road investment which they would be prepared to make to achieve an optimum return from their large expenditure on the vehicle. The extra road expenditures may be only what the users are quite willing and ready to pay, but the decision process for investment in roads gives the user no way of buying the extra road that he is prepared to pay for. Manufacturers pressure the user to buy more expensive motor vehicles, but pressure for a better road system is comparatively weak.

The financial problems of public transit systems are very different. The transit user seems unwilling to pay the full cost of the service he now receives. In Toronto, for example, the nonusers or irregular users are paying a subsidy, and properly so, to have the public transit system available if and when they may need it. Similar subsidies are desirable in other cities, although there is little justification for the pattern which seems to be emerging, of operating costs being borne by the user and capital supplied by the whole community. Decision by referenda for these capital investments has become common in U.S.A. but is still unusual in Canada. Aggressive action is needed to overcome the financial difficulties of transit systems.

A wholly equitable and adequate system of finance for all modes of urban transport is, therefore, a difficult achievement, but one which merits much greater attention and effort than it is currently receiving.

5.5 NATIONAL IMPLICATIONS

The following are some of the national implications of urban transport. It is suggested that there are a number of reasons why the federal government should assist other governments and the transport industry in the solution of urban transport problems.

5.5.1 Broad Long-range view

It is important for someone in Canada to take a broad long-range view of urban transport planning. At the national level is there a possibility of attaining the Nationwide broad long-range perspective that is required for the far reaching policy decisions affecting urban transport.*

5.5.2 Research and Development

Urban transport research and development can be assisted by the federal government or undertaken at the national level. There is much needed research which can not be justified for any one city alone or for any one province alone. This could be organized on a national basis making full use of international cooperation to conserve scarce resources and involving the full cooperation of all involved governments and agencies.

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*See Ref. No. 10

5.5.3 Federal Agency Co-ordination

Since the senior level of government is necessarily involved in a number of undertakings which have a significant effect upon urban transportation, and since it is very important to have effective coordination between the various Federal agencies that are involved, some necessary direct action at the federal level to bring about coordination of urban transport planning seems likely and desirable. Among the departments and agencies of the federal government whose activities relate to urban transport are:

- Central Mortgage and Housing Corporation;
- Ministry of Transport, including:
  - Canadian Air Transport Administration
  - Transportation Development Agency
  - National Harbours Board
  - Canadian Surface Transport Administration;
- Department of Public Works;
- Ministry of State for Urban Affairs;
- National Capital Commission.

5.5.4 National Economic Policy and Control

Approximately 15% of Canada's gross national product is urban transportation. * This is not only a very large part of the total economy, but also a sector of the economy with which government has a necessary and substantial direct involvement and leverage as discussed in Section 4.1. Therefore, serious attention should be given to the possibility of using urban transport as a means of influencing the overall economy toward the achievement of appropriate national goals.

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*This estimate is based upon the per capita urban transport expense by city size as given later in this report.

National accounting was first examined as a means of relating transport efficiency to national policy. "A nation's economy has too many dimensions to be pictured easily and without distortion in a single economic accounting system." * Thus, it is not surprising that no single satisfactory national accounting measure was found in this project.

In Chapter 10 the methodology is developed for aggregation to national totals from information on each of the three generalized cities. But, as explored in Chapter 6, the national income and product measurement accounts, as such, do not give an adequate measure of urban transport efficiency.

It would have been desirable to work with urban input-output analysis, but the lack of a sufficiently fine break-down of information made this impractical. Economic indicators, in terms of cost savings, and social indicators have, therefore, been developed in Chapters 8 and 9. These are adequate for the evaluation of primary benefits, specifically total transport cost savings, which are achievable through changes in transport efficiency. The major thrust of the project is to achieve evaluations in terms of these economic indicators, and also the social indicators.

In addition to these direct benefits, urban transport may also be used to achieve, indirectly or secondarily, progress toward a number of other significant national goals, specifically:

<u>Improved Foreign Trade Balance</u>

Urban transport efficiency improvement will tend to lower the cost of production and thus, possibly, to improve Canada's international competative position for goods manufactured in our cities. This benefit is uncertain, of course, because there is no guarantee that the savings will be distributed in such a way as to improve our foreign trade balance, but nevertheless this is a possibility though an indeterminate one.

<u>Lessen Regional Disparities</u>

There is a slight possibility that Urban Transport might be used to lessen regional disparities by improving the efficiency first in the less advantaged cities. This is unlikely to be a big factor, however, because the less advantaged cities tend to be smaller with slower growth rates and lesser urban transport problems.

* quotation from p.2 of ref. (50)

Smoothing Economic Peaks & Valleys

A traditional and good use for public works, such as capital intensive urban transport projects, is to step up expenditure in economic valleys and slow it down in the peaks. This brings benefits several ways. In the valley of high unemployment a low shadow price could reasonably be used for labor, thus, giving projects higher benefits. The wages distributed through the project, tend to stimulate the economy and the benefits from the project will be available to create savings at the time of the next peak.

CHAPTER 6

URBAN TRANSPORT EFFICIENCY

This chapter discusses the nature of urban transport efficiency and how we propose to evaluate means of improving this efficiency. The section headings are:

6.1 MEANING OF EFFICIENCY

In general, a more efficient activity is one which achieves the objective with a lesser expenditure of resources. Efficiency may thus be defined as the ratio of output to input in which output is a measure of goal achievement by the process and input is a measure of resources consumed in the process. Any one efficiency ratio becomes meaningful only if compared with another. A particular organization of production or service is more efficient than another if a greater output is obtained by the use of the same set of inputs, or if the same output is obtained by a smaller set of inputs.

If outputs are considered as benefits and inputs are considered as costs, then an efficiency ratio is seen to be very similar to a benefit/cost ratio.

The efficiency ratio may be expressed as

$e_c = \frac{B_c}{I_c}$ where

B_c - The sum of all the desirable values or outputs produced by the city. Some are related to the city as a human habitat. The outputs include:

a) exports from the city
b) goods and services consumed by the inhabitants of the city
c) intangible benefits or welfare items enjoyed by the inhabitants.

I_c - The sum of the inputs which are used to produce B_c. They include:

a) imports to the city
b) labour resources used in the urban area
c) environmental deterioration or other disbenefits.

The great difficulty in the practical use of efficiency measures is that of expressing all items in the same units which, of course, is essential for a meaningful ratio.

6.2 WELFARE ECONOMICS OR SOCIAL INDICATORS

Better government is more efficient in that it achieves a better use of resources in advancing the public good. Indeed the act of striking any governmental budget involves a conscious planning of resource allocation. The resources thus allocated are economic resources. This does not imply, however, that the purposes of resource allocation are purely economic. In fact, a considerable proportion of public expenditures is allocated to advance such objectives as the alleviation of poverty, and the advancement of culture and education. Public action in city planning and environmental control, for example, are aimed at the improvement of the city as a human habitat for social more than economic reasons. Even the apparently prime economic objectives of increased production and employment have underlying social goals.

Definition and quantification of social objectives are very difficult. When the advancement toward one socially desirable goal involves a conflict with the advancement toward another goal the decision of what constitutes the optimum balance is a function of the policy-makers. The duty of the analyst is to display different options and trade-offs, in such a way as to help the policy makers to take their decisions, but without encroaching on their field of responsibility.

For analytical purposes this problem may be expressed in terms of efficiencies, as has been done in Section 6.1 or in terms of trade-offs as follows:

> The formal condition for optimization of resource allocation is that the benefits from the last (marginal) dollar allocated to any one objective should equal those from the last dollar allocated to any other objective. Without this condition the overall position of the society could be improved by shifting the expenditures from the allocation producing lower benefits - at the margin - to those producing higher benefits.

Either optimizing approach would give the same results. Each suffers the same handicap - valid analysis requires that all costs and benefits be expressed in the same units.

The "welfare economic" approach (see appendix C) does just that or at least proports to do so. In welfare economics one uses monetary units to quantify the comlete welfare function. Thus all numerator items in an efficiency ratio, including intangibles, are expressed in dollars as are all denominator items, including environmental deterioration.

This conversion of all values to a common unit like dollars appears unattainable and, even if attainable, lacks popular appeal. People feel that social welfare is advanced by enriching the cultural life of the population and improving its health, but the measurement that would bring a well-baby clinic and a symphony orchestra to a common denominator, and that would also be operationally meaningful, is hardly conceivable. At the same time, a need exists to assist the policy makers to choose from an increasing number of options involving this type of allocation.

A second main avenue of approach to the problem of allocating resources among the competing goals of society is the use of both economic and "social indicators" together to describe the various situations. This approach accepts a mixture of units and, because of this, the results of an evaluation cannot be expressed by a single number by which projects can be ranked. Rather each project or alternative is described by a series of indicators in different units. The user of the results must then do his own trade-off analysis in comparing schemes and ranking them.

Both the "Welfare Economics" and the "Social Indicator" approaches have a long and distinguished tradition. The "social indicators" approach can be traced to eighteenth century writers on "Political Arithmetick" and "Cameral Science". Welfare economics, although formally introduced in the 'twenties', by Pigou, can claim a sustained development from the works of Pareto during the second half of the last century.* Recently, work in both directions has been greatly intensified in response to the needs of government.

For purposes of this project a combination of "social indicators" and economic or monetary indicators, has been employed. The value of the welfare economics approach is recognized and discussed more fully in appendix C. The necessary and accepted conversion factors have not been available, however, to express all social values in monetary terms, and, in our judgement, the decision makers are not prepared to use a single indicator. Indeed the current popular objection to the so called "cult of the GNP" and appeal for a zero growth rate are warnings against evaluations in terms of a single monetary unit.

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* Pareto had distinguised careers in three disciplines - engineering, economics and sociology; his career is an example of the value of inter-disciplinary cross-fertilization, as well as of the common centre of interest of those disciplines.

6.3 ECONOMIC INDICATORS

Even using the social indicator approach, we still employ economic indicators as far as possible to measure the degree of achievement of social goods. Even though, because of mixed indicator units, efficiency ratios as such are not useful, nevertheless, meaningful economic efficiency measures may be achieved by holding the output constant at the neutral path condition and varying the input. Input differences between any scheme and the neutral path conditions, then become measures of efficiency improvements, expressed as savings or benefits.

The benefits which are conveniently described in monetary terms are referred to as 'economic benefits' and are expressed as monetary savings. They are generally the items which show in the national accounts. The usefulness of economic indicators to gauge transports contribution toward human goal achievement is considered in Sections 7.2 and 7.3 and the character of such indicators is developed in Chapter 8.

6.4 SOCIAL INDICATORS

Social indicators have been used to quantify some of those important costs and benefits which we are unable to express in dollars. Because of the mixed units, ratios cannot be used and, therefore, for each scheme, it is necessary to express the costs and benefits in terms of the several indicators. Some of the long range, very important benefits of improved quality of neighbourhood life for example,can only be expressed in terms of the social indicators. The social indicators are thus used for describing those social benefits which do not normally show in the national accounts.

The usefulness of social indications to gauge transports contribution toward human goal achievement is considered in Sections 7.3 to 7.7 and the character of the social indicators selected for this project is discussed in Chapter 9.

CHAPTER 7

TRANSPORT AND HUMAN GOALS

This chapter suggests a comprehensive human goal matrix and the parts of this matrix where urban transport efficiency improvements may contribute to goal achievement. The section headings are:

7.1 HUMAN GOALS

Efficiency concerns the effectiveness of the use of resources to attain goals. It is necessary, therefore, in developing a rational efficiency evaluation methodology, to start with goals. The basic goals of society are, of course, social goals.

Therefore, we have established a goals matrix and utilized both economic (or monetary) and social indicators, as appropriate, to measure the degree of achievement of particular goals.

Although there is much current discussion of the broad goals of society*, there is a serious lack of a clear, precise, widely-accepted goals matrix. Figure 7f1 presents the goals matrix which has been developed for the purposes of this project, using the current liturature and considerable judgement. It has been conceived as a logically complete set of human goals arranged for convenient expansion to all sub-goals which may be articulated.

Figure 7f2 suggests some of the interactions between this set of goals and government policy. Referring to figure 7f2, "Transport" and "Activity Distribution" (land use) are in dynamic interaction in the centre of the urban system. Government policy may exert an influence upon the system in four ways:

- transport expenditures and regulations
- other land service expenditures
- land use regulations
- people service expenditures

Some of these policy tools have a direct effect upon the goals. For example:

- the police system on public order and safety
- health services on health and survival
- education services on vocation
- social welfare and recreation on social well-being

These direct relationships need not be considered in this evaluation which is concerned principally with transport.

The remainder of this chapter discusses the goals which are shown on figures 7f1 and 7f2 and the following Chapters 8 and 9 describe the social and economic indicators which have been used to measure the degree of goal achivement.

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* See for example E.C. Manning "White Paper on Human Resources Development" (30), R.A. Bauer "Social Indicators" 1966 (23) and also ref. (9).

7.2 MATERIAL WELL-BEING

By material well being we mean having a good supply of the material things of life. It is certainly reasonable to measure material well being in monetary terms. Monetary income is used to purchase material items such as food, clothing, housing, recreation and entertainment, transportation and savings.

Although there is, no doubt, a relationship between material well being and real income measured in monetary terms, the relationship need be neither direct nor linear. Considerable literature exists on the valuation of income and the diminishing utility of money with income increases.

Average per-capita income may be misleading as an indicator of material well being, if it is not combined with some indication of income distribution. People below the poverty line, for example, require special attention; their problems are certainly not displayed by considering average income. To assess different transportation systems and their affect upon income distribution and poverty is desirable, but difficult.

7.3 SOCIAL WELL-BEING

A person can have material well-being or "freedom from want" while living alone on an island or in a space capsule, provided the island or capsule is stocked with food and all the other desired material things. By contrast, social well-being is good relationships with other people: in its simplest form, loving and being loved. In our complex society, it involves aspects such as belonging, participating, status, respect, power, tolerance, dignity, freedom and challenge. In the U.S.A. one aspect of social well-being, social mobility, is a crucial issue becuase of the lack of equal opportunity for white and black*. One might, at first, suspect that transportation has very little to do with social well-being and yet "status" influences the selection of personal transportation. The marketers of automobiles are well aware of this consideration, as is evident in automobile advertising.

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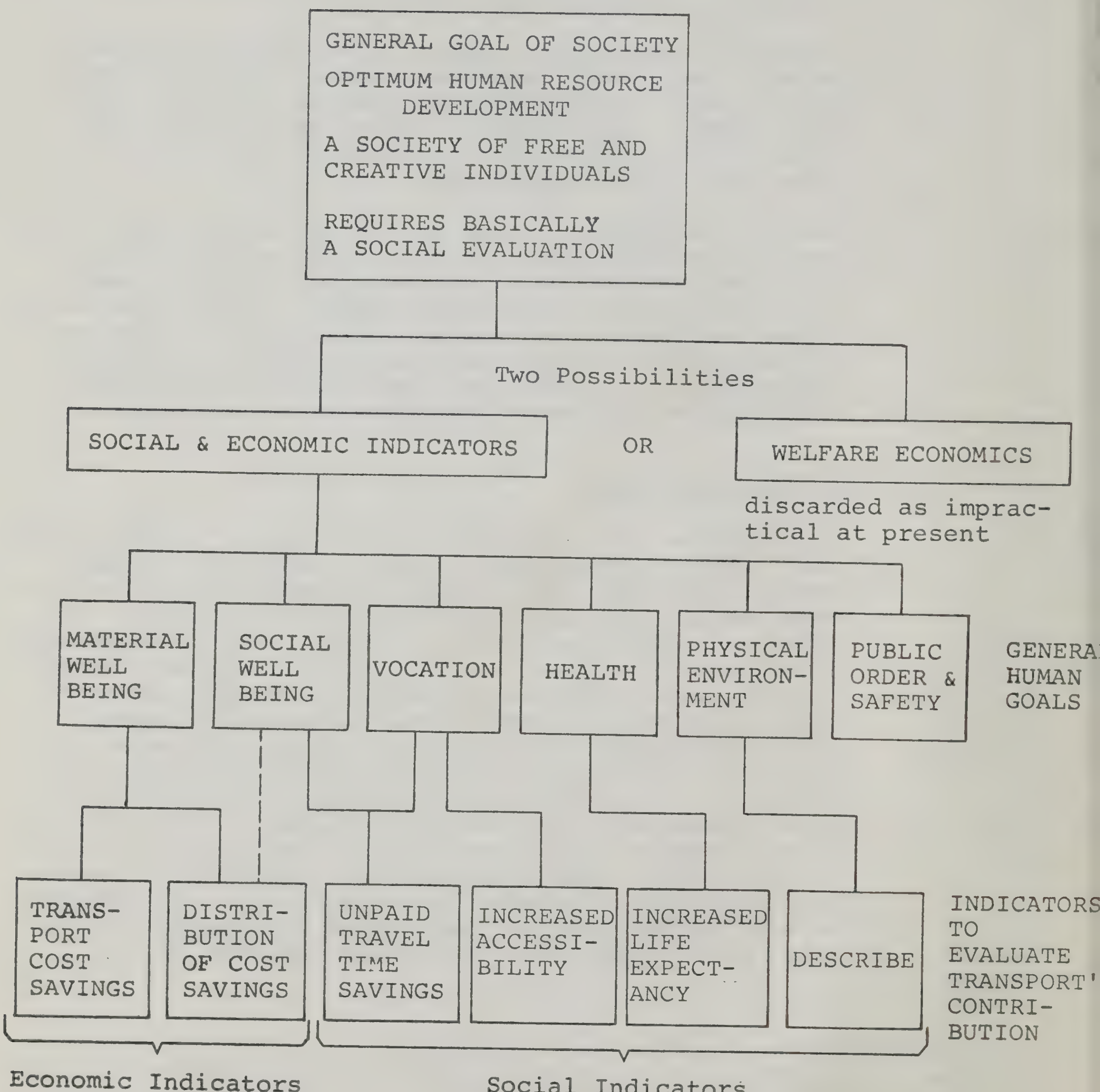
* See "Toward a Social Report" U.S. Dept. H.E.W. 1969 (9)

FIGURE 7f1

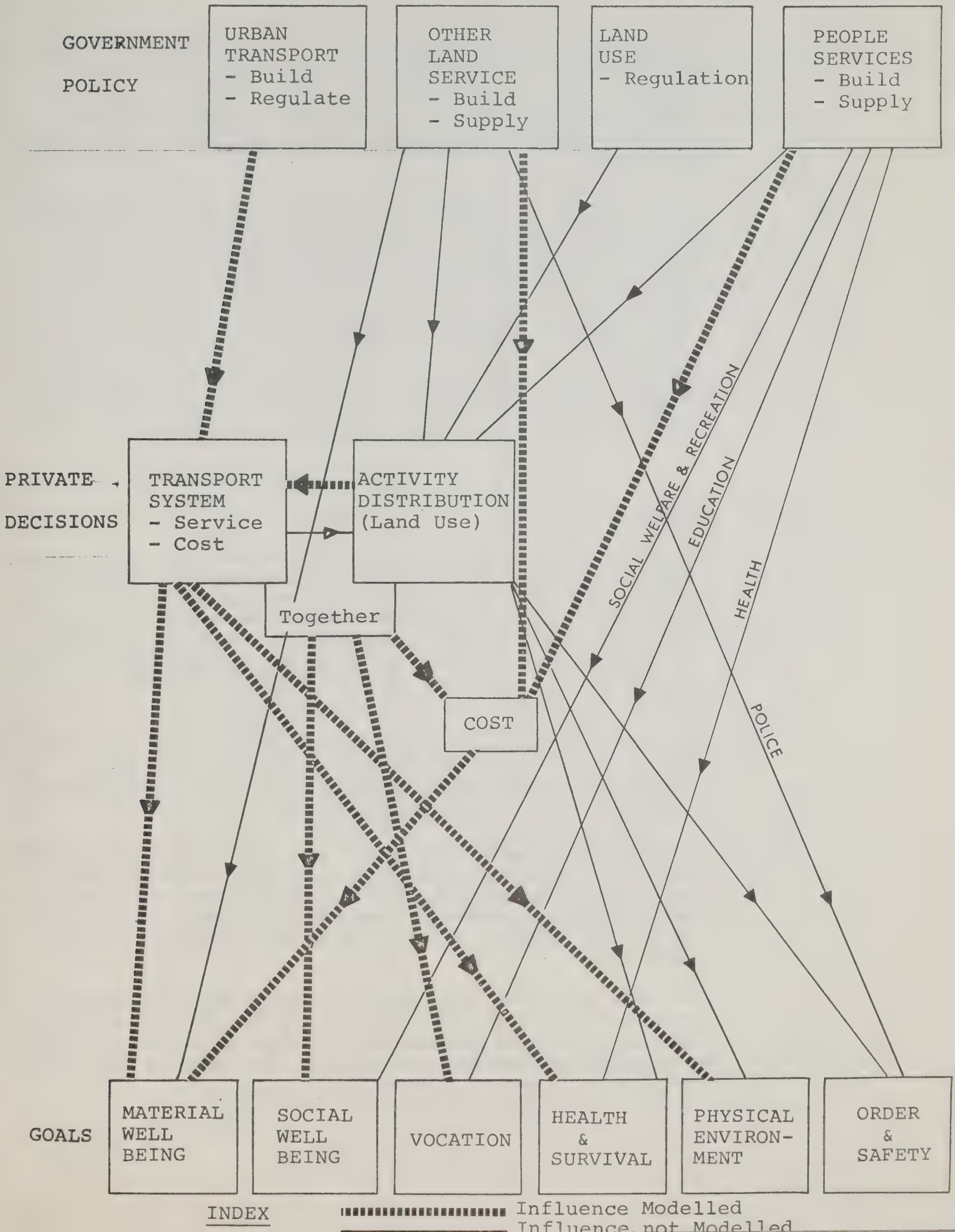
PUBLIC GOAL DEFINITION



N. D. LEA & ASSOCIATES LTD.

FIGURE 7f2

INTERACTION BETWEEN POLICY & GOALS



Very little serious study is being done on this subject except through motivation research which is pursued primarily by people who sell products to the public. It may be a very fruitful field for more intensive study, particularly where a public service such as transit is marketed in competition with private service.

The subject is intimately entwined, however, with the other social goals which make it exceedingly difficult to devise a social indicator to measure social well-being. Furthermore, how transport contributes directly to social well-being is not known. For some people the trip to work may be a very rewarding social experience and for others a complete bore. Since people generally try to minimize their travel time, we can assume that non-travel time is more rewarding than is travel time. Therefore, for transportation purposes, minimizing travel time is the best indicator we could find for the maximizing of social well-being.

7.4 VOCATION

If vocation is used in the broad sense of a captivating human activity, then it includes education, leisure activities and employment. One of the measures of the quality of education could be the degree to which it captures the learners. And for an increasing number of people in our society, education is becoming an end in itself, as well as, or rather than, a means to an end.

We are gradually experiencing more and more leisure and recreation. Governments are taking an increasing interest in providing facilities, so that leisure and recreation may be personally rewarding.

Employment should be gainful and satisfying, with good working conditions. Many people find a great deal of personal satisfaction in their work, partly perhaps because of the concept that work is good. Certainly it is a very unhappy situation to be involuntarily unemployed.

We have not found any social indicator for measuring the quality of vocation, either with regard to employment, recreation or education. This could be a fruitful area for research, but it is far outside the goals of this particular project.

Transportation, however, clearly makes a contribution to employment, recreation and education, by opening more opportunities for these activities for the individual, as the level or quality of transportation is improved. Thus, the transportation measure of "accessibility" may well be the best indicator that is available of the contribution of transportation to vocation.

The savings which may be effected in travel time are a significant benefit to vocation. In some transport studies, savings in unpaid time are converted to dollars at a rate of as low as 50¢ and in others as high as $4.00. We have chosen to quantify this benefit in hours for reasons discussed more fully in Chapter 9. Reduced unpaid travel time is, therefore, considered a significant social indicator of benefits in vocation. It is useful to distinguish between several types of time consumed in transport as discussed in Section 9.2.

7.5 HEALTH AND SURVIVAL

Certain health costs are included in income which is considered a measure of material well-being. Therefore, one must be careful to avoid double counting on this item. For the same expenditure on health, however, there may will be varieties of achievement. Some measurement of survival or life expectancy is possible. At the present time, it is difficult to find any better measure of the quality of the health of a nation.

Transportation has a bearing upon health and survival, in providing access to health services and through safety measures improving health by reducing accidents.

Improved transport conditions will, therefore, contribute to the social goal of health and survival. Meaningful evaluations of this contribution can be made through transport studies and this should contribute to well-informed political action. Data now available can be used to give some indication of the effect of transport changes upon life expectancy as discussed further in Section 9.4.

7.6 PUBLIC ORDER AND SAFETY

Crime, war and insurrection rob people of the freedom from fear which is considered a basic right. Therefore, the public forces of law, order, justice and the militia seek to achieve the individual's peace and security.

We have available at the present time some statistics on the rates of crime, but there is no really satisfactory overall crime hazard index and very little understanding of how to determine the most effective course of action to change such an index. The design of a particular community, no doubt, has some bearing, but probably much less than the degree of law enforcement. The character of the transportation system is probably quite a minor factor, except as it contributes to physical environment and as transport is provided for enforcement and emergency services. We have, therefore, not attempted to use a social indicator depicting the level of public order and safety.

7.7 PHYSICAL ENVIRONMENT

The individual lives in contact with his physical environment through his senses of touch, sight, taste, smell and hearing. To a considerable degree, the physical environment is determined by housing. This will not be considered here because this would be double counting of a factor that has already been considered under material well-being.

The community has a special responsibility, however, to effect control of the public environment. Here public transportation facilities are a significant factor. They effect the noise level, the air quality and the aesthetics of the community. No doubt, one of the reasons for people preferring low density living is to achieve a dilution of objectionable noise, smell and sight. It is possible that somewhat higher densities might be desired if we could achieve good control of fumes, noise and unsightly conditions. There have been no experiments, however, to our knowledge, carried out along this line, and very little empirical knowledge is available. If it were possible, however, to make higher density more attractive in this way, there could be worthwhile savings in transportation.

The noise level is one important dimension of the physical environment. Unfortunately, the scientific study of noise as a desirable or undesirable characteristic of the physical environment is in its infancy. A recent and extensive study made in Britain shows a very great variation in subjective evaluations of the severity and objectionableness of particular noises*. There is a practice in some ultramodern offices to artificially create a certain level of "white noise" to improve working conditions. This practice creates an

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* See results of London noise survey (25)

"ambient" noise level. The importance of the ambient level is illustrated by the troublesome noise which the beating of ones heart makes, if one is placed in an exceedingly quiet sound absorbent room. The noise from motor vehicle traffic and from aircraft is a very significant factor in the physical environment. The subject is properly receiving intensive attention around the world. At present, we do not know what are the tolerable levels of noise or even the desirable levels, nor do we know how much it costs to reduce the noise level by a certain amount. Further research in the subject of aircraft noise, in particular, but all transportation noise in general, is most important, and is being aggressively undertaken in the United States and in Europe.

The automobile is one of the most significant elements contributing to air pollution. The problems created by automobile exhaust have been very acute in the Los Angeles area and are being submitted to intensive research. Both the physical phenomena involved and the health hazard for human beings are receiving careful study. It is likely that for Canadian purposes we can rely to a large extent on the results of the research work which is receiving high priority in the United States*. Presently, there is available no completely satisfactory index of the health hazard from motor vehicles exhaust. Quite possibly, however, for Canadian purposes the health hazard will turn out to be of less importance than some index of pleasantness or of air freshness. After all, fresh air is one of the big drawing cards to the country.

There is reason to believe that the total physical environment is more than the sum of its parts and, therefore, a useful approach might be to evaluate various total environments. This would appear to be practical because society appears to naturally divide itself into neighbourhoods**. Once the neighbourhood is adopted as a research unit for testing liveability variations, then exciting possibilities are open for the experimental construction and testing of many significantly different types of neighbourhood. Transportation would be an important contributing factor to such a project, although probably not the most important part. A significant and important aspect of the design of such research projects, however, would be to establish a neighbourhood transportation system that simulates future technological possibilities. This

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* as suggested by J.L. Sullivan at CGRA 1968 (26).

** see for example ref. (8) pages 164, 424 & 440.

approach opens the possibility of using the market place to evaluate environment. The present teacher's salary differentials between cities, as an example, illustrate that such a market mechanism is indeed already at work.

In the light of the above discussion, it is not pratical now to use any indicators of physical environmental quality for purposes of this current study. We have, therefore, for each urban transport proposal evaluation, included a brief qualitative description of its anticipated effect upon the environment.

CHAPTER 8

ECONOMIC INDICATORS

This chapter describes how economic indicators may be used, and how they are used in this project, as monetary measures of the degree of achievement of social goals. The following headings identify the indicators:

8.1 ECONOMIC INDICATORS

It will be observed from Fig. 7tl that there are two economic indicators which are proposed for measuring transports' contribution to the degree of achievement of certain social goals, principaly, "Material-Well-Being" and secondarily, "Social-Well Being". These two economic indicators are:

- transport cost saving and
- distribution of cost saving

8.2 TRANSPORT COST SAVING

Transport cost saving, can be shown to be:

- an indicator of economic efficiency improvement
- of the same effect as a price decrease and
- a minimum measure of the increase in real disposable income.

Whenever we refer to transport cost we intend to include all elements of total transport cost such as:

- capital cost of the vehicle and of the roadbed
- maintenance costs for vehicle and roadbed
- cost of operations
- paid time of vehicle crew and travelers

For comparison, of course, discounting must be used to bring all costs to present worth or to an equivalent annual cost.

8.2.1 Cost Savings Indicate Economic Efficiency Improvement

Transport costs are input items in the denominator of the efficiency ratio. (See Section 6.1). They are made up of wages, materials and imported goods. If a change is made in the transport system such that the transport cost is decreased but the transport service is unchanged, then there are two simultaneous effects on the efficiency ratio. First, the denominator is decreased by the amount of the cost reduction, and second, the numerator may be increased because the resources released from transport may be redirected to buy more consumer goods and services. The latter is an example of secondary benefits.

Thus, savings in transport costs are a direct improvement of efficiency and the amount of the saving is a measure of the efficiency improvement.

One may ask whether purchased transport services should not be treated in the same way as other consumers' goods and services, i.e., as a final output. The reason why transport services are treated as inputs is that the usual objective of people is not to travel or move goods as an end in itself, but rather to use travel as a means to achieving some other objective. Persons and materials are moved for production purposes (e.g. travel to work, bringing materials to factories or goods to stores) or for consumption reasons (e.g. travel to shopping or entertainment). Thus, transport should be considered as an input which is necessary for the achievement of production or consumption.

8.2.2 Cost Saving Amounts to a Price Decrease

Transport efficiency improvements may make possible the shortening of trip lengths. For example, urban transport costs may be reduced by a more efficient layout of transport facilities whereby, travel between two points may be accomplished over a shorter route. Such an efficiency improvement has the same effect as a transport price reduction. Indeed, most of the efficiency improvements which we will be considering are of a type which have the same effect as a price reduction.

The savings indicated by calculations of transport cost reductions are social opportunity cost reductions only if the resources thus released can find an alternate use, which is equivalent. This assumption is quite realistic, given a reasonably functioning price mechanism, a high degree of labour mobility and a moderate degree of unemployment.

8.2.3 Cost Saving - A Minimum Measure of the Increase in Real Disposable Income

Transport cost saving without decreased quantity or quality of service is a minimum measure of the increase in real income. Income is measured - by necessity - in money terms. As an index of material welfare, income is the purchasing power available to acquire a desirable set of goods and services. An increase in money income does not necessarily mean an equivalent increase in purchasing power. In fact, in periods of inflation a constant money income means a decrease in purchasing power. Real income is, thus, defined as the purchasing power of money income. In order to measure the changes of real income, changes in money income are multiplied by the appropriate index of price changes.

The disposable income during the base year is defined as follows:

$$q_{o1}\ P_{o1} + q_{o2}\ P_o + \ldots\ldots + q_{on}\ P_{on} + S_o + f_o = Y_{o_G} - t_o$$

where
- $q_{o1}, q_{o2}, \ldots$ - quantities of goods and services purchased during the base year
- $P_{o1}, P_{o2}, \ldots$ - prices of goods and services during the base year
- S_o - saving during the base year
- f_o - free service of public authorities during the base year
- Y_{oG} - gross income, inclusive of transfer payments, subsidies, etc., during the base year
- t_o - taxes during the base year

Similarly for any subsequent year i, the disposable income would be:

$$q_{i1}\ P_{i1} + q_{i2}\ P_{i2} + \ldots\ldots + q_{in}\ P_{in} + S_i + f_i = Y_{i_G} - t_i$$

(subscript i denotes current year; meanings of other symbols same as above.)

In order to calculate the change in real income, we could either adjust for every price change, or adjust $(Y_{iG} - t_i)$ by the cost of living index.

Let us now assume that the price of item j declines... $P_{oj} > P_{ij}$... and the quantity of j remains constant... $q_{oj} = q_{ij}$. This change would be equivalent to an increase in real disposable income by $q_{oj}\ P_{oj} - q_{ij}\ P_{ij}$. If such an increase were taxed away, the consumer would be left as well off as before. If he were allowed to spend it as he pleased he would be better off, even if he spent all these savings on the increase in consumption of the same goods. The real income, thus, increases by at least the amount of the saving due to the price decline.

If such a decrease in price happened as the result of government expenditure, a compensatory change in money disposable income would need to be introduced. This compensatory change would be an increase in taxes to cover the costs of improvements. If such a compensatory change were introduced, the net increase in real disposable income (E) would be:

$$q_{o_j}\ P_{o_j} - q_{i_j}\ P_{i_j} - t_c = E$$

where t_c is the compensatory tax to pay for the costs of the improvement.

In the case of total transport cost, however, items such as t_c are already included as part of the total cost. Thus, the real disposable income is increased by at least the amount of the transport cost saving.

8.2.4 Extra Benefits

Note that transport cost saving gives a minimum valuation of benefits. For example, a decline in transport costs also increases the freedom of choice of location. More locations become attractive. Free public services such as parks, cultural centres and the like, become more accessible and thus, their value increases. An increased freedom of choice or an increase in possible choices, increases the satisfaction obtained from the purchasing power at the individual's disposal. The proposition as applied to transport and residential choice is developed further in Appendix A.

If transport is made more efficient, some people choose to use the benefits so gained for travelling farther to live at lower density. People do this only because the benefits they achieve in this way mean more to them than if they used the extra available income for some other purpose. The fact that they use the benefit to buy extra transport in no way invalidates the use of potential transport savings as a minimum measure of the benefit. It does mean, however, that in quantifying the savings, one must be careful not to include the extra travel as a cost*.

8.3 DISTRIBUTION OF COST SAVING

As indicated in Section 7.2, it would be desirable to supplement information on average cost savings by information on the distribution of these savings throughout the population. This is succeptable to quantitative analysis, but since practicaly none of this type of analysis has been done in Canada, we have been unable to give any consistent information concerning the distribution of savings. Where some hints are available from U.S. work, these will be mentioned. It would be an important and productive area for research.

The indicator of the distribution of cost saving could be some simplified distribution function. The simplest and most dramatic would possibly be simply the number of people who are moved above the poverty line.

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* see also report sections 11.3.3 where this subject is developed further.

CHAPTER 9

SOCIAL INDICATORS

This chapter explores briefly the usefulness of social indicators and describes how they are used in this project as indicators of the degree of achievement of human goals. The following headings identify the social indicators employed:

9.1 SOCIAL INDICATORS

9.2 UNPAID TRAVEL TIME SAVING

9.3 ACCESSIBILITY INDEX AND RATIO

9.4 INCREASED LIFE EXPECTANCY

9.1 SOCIAL INDICATORS

The use of transport savings as an indication of increased real income, and, therefore, as a measure of benefits or improved efficiency, accounts for only one part of the effect of transport changes upon urban efficiency. It is recognized on Figure 7f1, that economic indicators are useful only to measure progress toward two of the goals and that social indicators are required for five goals.

Significant philosophical and politican issues are involved in the selection and use of social goals and social indicators in technical work. Welfare economics* is comfortable for the technical person because conflicting goals are resolved in the least common denomination of dollars using the capitalistic principle "a-buck-is-a-buck". Social indicators point to a very different principle for resolving goal conflicts - the political and democratic ideal of "one-man-one-vote".

There is indeed a basic conflict here which we describe as between the democratic principle (one-man-one-vote) and the capitalistic principle (a-buck-is-a-buck). The use of social indicators does not resolve this conflict, but it does recognize it, and, as the techniques improve, will hopefully provide the information so that decision makers will be better able to resolve the conflict in real life situations where many non-economic considerations must be weighed in taking decisions.

The renewed interest in social indicators is largely related to disillusionment with national income growth as <u>the</u> indicator of the success of national policy. The persistence of a hard core of poverty in spite of the impressive increase of national products; flagrant abuse of common resources, such as pure air or water, existing social tensions, fundamental and unresolved choices facing the society because of rapid changes of environment due to scientific progress, are but a few problems in the broad spectrum of issues with which governments must deal and which overshadow the problem of increasing the growth rates**.

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* see report Section 6.2 and Appendix C for a further discussion of Welfare Economics

** Pre-occupation with growth is also attacked by some prominent welfare economists, such as Mishan in his book <u>What Price Economic Growth?</u>, while the conflict between maximizing <u>present</u> welfare <u>versus</u> growth is receiving considerable attention.

There is, at the present time, a growing awareness and interest in the development of social indicators or other means for improving our ability of measuring the degree of achievement of various human goals *. In spite of the impressive literature on the subject, and fruitful inter-disciplinary cooperation inherent in this approach, the development of meaningful social indicators is quite embryonic.

Table 9t1, reproduced from 'Social Indicators' (24), lists the number of indicators thought to be relevant (not necessarily adequate) to the measurement of progress toward the social goals defined by the 1960 (U.S.) President's Commission on National Goals. Worth stressing is the fact that in the area of "living conditions", which is particularly relevant to this study, no relevant indicator is available for the majority of the specific goals. Furthermore, as noted by Bauer (24), "the criterion of relevancy is very loose indeed. It is, therefore, conservative to say that in 4 out of 10 goals on the list of the President's Commission, we would not even find data to wonder about".

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* Some of the most pertinent items in the growing literature on the subject are: U.S. Department of Health, Education and Welfare Toward a Social Report (9), a collection of papers on Social Indicators arising from the U.S. Space Administration (23), and Morris Hill's Goals Achivement Matrix for Evaluating Alternative Plans (24). Furthermore, in the United States, massive research programmes to the extent of $70 mil. p.a. are being proposed (8,p.363)

TABLE 9t1

AVAILABILITY OF INDICATORS RELEVANT TO NATIONAL GOALS FORMULATED BY PRESIDENT'S COMMISSION *

Goal Areas	Number of Specific Goals	Number of Goals to Which some Indicator is Relevant	Number of Goals to Which no Indicator is Relevant
The individual	6	3	3
Equality	3	2	1
Democratic process	11	5	6
Education	5	5	0
Arts and Sciences	8	2	5
Democratic economy	9	5	5
Economic Growth	9	9	0
Technological change	5	1	4
Agriculture	5	4	1
Living Conditions	10	2	8
Health and Welfare	10	10	0
TOTAL	81	48	33

* In Statistical Abstract of the United States (52).

Given the present state of the art, it is not possible to express the efficiency of urban areas in terms of any generally accepted social indicator or set of indicators. In Chapter 7, a goals matrix is developed and possible social indicators discussed to measure the degree of achievement. Only four indicators are suggested there, which, with the two economic indicators gives a total of six. This appears a small number, compared with the dozens suggested by some literature. We argue as follows, however,:

(1) We are seeking only indicators of the effect of transport changes upon goal achievements and

(2) If six schemes, as an example, are to be assessed by six indicators, then the person seeking to use this information to form a judgement is faced by a matrix 6 x 6 which is about as much as a person can comprehend.

The number of social indicators has, thus, been kept to the following minimum:

- Unpaid travel time saving
- Accessibility
- Life expectancy
- Qualitative description of environment

9.2 UNPAID TRAVEL TIME SAVING

Five categories of time are given in Section 4.3.5, namely:

- Emergency time
- Paid time
- Unpaid & wasted time
- Unpaid, but useful time
- Fun time

Although, we would have liked to use such a breakdown consistantly, unfortunately, the necessary information is not available to do this. Thus, for purposes of evaluation on this project, it has been found most practical to use only two categories of time: paid time and unpaid time.

The paid time involved in urban transport is evaluated in monetary terms. The time of the drivers of commercial vehicles, including emergency vehicles is, therefore, calculated in the analysis and multiplied by the average wage rate. Any reductions in this amount are, thus, shown in the economic indicator "transport cost saving".

All other time, namely the later three categories above, is grouped together in the one category of unpaid time. Since it is usually desirable to have the minimum amount of unpaid time consumed in transport, therefore, unpaid travel time saving, expressed in man hours per year, becomes a social indicator.

The time of drivers of emergency vehicles, has been taken in the analysis as part of the general category of paid time. Since the time of emergency vehicles is a very small proportion of the total - less than 1% of the total time and much less than 10% of the total paid time - the error introduced by the simplifying assumption is small and is conservative.

There has been great debate in the literature over the value to place upon unpaid time. Separation into the above categories might be helpful. The value to place on fun time should certainly be zero because the users would consider it a benefit to take more time. Fun

time, however, is probably less than 10% of the total social-recreational trip time and is probably less than 1% of the total time used in urban transport. The error introduced by lumping it together with other unpaid time is quite small. For both wasted and useful time, however, there is evidence from toll road studies for example, that people will pay more for the higher quality shorter time trip. Thus, various imput time values have been calculated by various investigators and agencies. We argue that savings in unpaid time are clearly not economic benefits in the same category as saving in food and wages. By quantifying the unpaid time in man-hours as a social indicator, it becomes possible for any user of the results to quickly convert this into dollars if he so chooses and at the rate he thinks appropriate.

The distinction between unpaid useful time and unpaid wasted time is a significant distinction, which it would be desirable to be able to quantify. Unfortunately, there is no simple way available for doing this. One complication is that the difference is really a range rather than two discrete categories. The best that can be done under the circumstances is to estimate and describe the item when it is of consequence. This might occur for example, with some new transport technology.

9.3 ACCESSIBILITY INDEX AND RATIO

Time and accessiblity, as discussed in Section 7.4, are both indicators of the degree of achievement of the social goal of "vocation" which involves work, education and other opportunities for achieving personal fulfillment.

Accessibility is conceived as an index of the number of opportunities or people who are within a convenient range of the location for which the accessibility is being evaluated. There have been a number of mathematical formulations of accessibility. The difference between them is not great, but there is no generally accepted measure of accessibility.

For the purposes of this project two measures of accessibility have been developed. Accessibility index and accessibility ratio. Both measures are developed for work and non-work purposes by auto mode and transit mode - i.e. auto work accessibility; auto non-work accessibility; transit work accessibility; and transit non-work accessibility.

The accessibility index, A, of an area is defined as follows:

$$A_w \text{ (Work accessibility index)} = \sum_{i=1}^{x} a_{w_i} = \sum_{i=1}^{x} E_i \left(2P_T - \sum_{n=1}^{4} K_n P_n\right) \times 10^{-6}$$

$$A_o \text{ (Non-work accessibility index)} = \sum_{i=1}^{x} a_{o_i} = \sum_{i=1}^{x} P_i \left(2P_T - \sum_{n=1}^{4} K_n P_n\right) \times 10^{-6}$$

where: P_T = total population of the area
P_n = population within time range n from zone i
K_n = rating constant of time period
E_i = employment of zone i
P_i = population of zone i
a_{w_i} = work accessibility for zone i
a_{o_i} = non-work accessibility for zone i
x = total number of zones in the area.

The values of n and K_n are as follows:

n	Time range from zone i (min)	Kn
1	0-20	0.0
2	20-39	1.0
3	40-59	2.0
4	60+	3.0

Examination of the above indicates that the maximum accessibility index is achieved when the time from all zones to all other zones in the area is less than 20 minutes (n = 1 and K_n = 0) and is defined by the following equations:

$$A_w \text{ (Maximum)} = 2P_T \sum_{i=1}^{x} E_i \times 10^{-6}$$

$$A_o \text{ (Maximum)} = 2P_T \sum_{i=1}^{x} P_i \times 10^{-6}$$

and the accessibility ratio is defined as the ratio of the actual accessibility index to the maximum accessibility index for the purpose and mode under consideration.

9.4 INCREASED LIFE EXPECTANCY

The most practical way of quantifying the effect of traffic accidents upon health and survival is probably through life expectancy. This approach may be illustrated as follows for Canada as a whole:

There are approximately 1600 urban traffic fatalities per year in Canada. The average age of the persons fatally injured in traffic accidents is 34.8 years, whereas the average age at death in Canada is 60.9 years. Thus, on the average, traffic accidents have shortened by 26.1 years the lives of those fatally injured in them. Since the deaths occurring in this way are approximately 1% of the total deaths in Canada, then the Canadian average age at death might be increased from 60.9 years to 61.2 years if all urban transportation fatalities were eliminated. This example does not consider either the effect of traffic injuries which are not fatal, or nervous damage caused by excessive stress. Neither does it consider the suicides and deaths by heart attack which are counted as traffic fatalities, but which would probably occur in some other way, if all traffic fatalities were eliminated.

Of course, it is not possible to eliminate all urban traffic fatalities, but there is a great deal that could be done to reduce the rate. Transit has a lower fatality rate than automobile travel. Indeed, practically the only transit fatalities are suicides. Grade separations reduce pedestrian fatalities and expressways and freeways have a lower accident rate than at-grade facilities. If one were to implement all of the improvements that have been proposed, with regard to the use of transit and the building of grade separations and the building of freeways and expressways, then the traffic fatality rate might be reduced by about 30%. This reduction would result in an approximate increase of the average age at death from 60.9 years to 61.0 years. A similar improvement might be achieved be better driver education and stricter driver licensing and vehicle inspection, although there is no data to prove this.

CHAPTER 10

GENERALIZED CITIES AND NATIONAL AGGREGATES

The analytical approach to obtaining national aggregate results for Canada has been to represent all Canadian cities by three generalized ones. This chapter describes the characteristics of these generalized cities. The following headings are used:

10.1 SELECTED GENERALIZED CITIES

- 10.1.1 City A
- 10.1.2 City B
- 10.1.3 City C
- 10.1.4 Expense Distribution

10.2 NATIONAL POPULATION AGGREGATES 1966-2001

10.3 NATIONAL INCOME AND EXPENSE AGGREGATES 1966

10.1 SELECTED GENERALIZED CITIES

The methodology for the project, as established in the contract, requires that all Canadian cities will be represented by three generalized cities as follows:

	Present Population (1966)
City A	125,000
City B	500,000
City C	2,000,000

10.1.1 City A

City "A" is representative of about 38 Canadian cities: Between 25 and 300 thousand in population. The characteristics of City A have been derived by giving particular attention to the following metropolitan areas:

Kitchener	192	thousand 1966 population
Saskatoon	116	" " "
Thunder Bay	98	" " "

For the purposes of national agglomeration, the populations of some 71 cities, each containing between 10 and 25 thousand inhabitants, have been added to that of the 38 cities. This resulted in a 39% increase in the population of that group. As shown in Table 10t3, 32 Type A cities are required to simulate Canadian 1966 conditions.

The characteristics of City A and the travel that takes place in it have been selected as representative of the average present conditions for cities in the 25,000 to 300,000 population range. City A has a good system of arterial streets and a few miles of a new freeway. There is some congestion on the downtown arterials for about 20 minutes in each rush hour. A city owned bus line struggles to keep the deficit down while giving minimum service. The present per capita income in City A is $1,950 per year. Approximately 14% of this income is used for shelter and 19% for urban transportation. The population, transport, income and expense characteristics of City A are summarized on Tables 10t1 and 10t2. The outline of the zones and the transport network for analysis are shown on drawing A-10.

10.1.2 City B

City B represents 7 Canadian cities of between 300 thousand and 1 million population in 1966. The characteristics of City B have been derived by giving particular attention to the following metropolitan areas:

Winnipeg	509	thousand	1966	population
Hamilton	449	"	"	"
Edmonton	401	"	"	"

City B has a well developed arterial street system and some 15 miles of freeways, largely located within or just outside the suburban fringes of the city. The automobile is the dominant mode of person transport, although there is a reasonably good bus system, particularly throughout the more dense central part of the city. City B contains a well developed central business district of about 2.2 square miles with a population density of about 25 thousand per square mile.

The overall density is substantially higher than in City A, which is due partly to the dense central core and partly to the suburbs being somewhat more dense than in City A.

The present per capita income in City B is $2,000 per year. Approximately 14% of this income is used for shelter and 21% for urban transportation. The population, transport, income and expense characteristics of City B are shown on Tables 10t1 and 10t2. The outline of the zones and the transport network for analysis are shown on drawing B-10.

10.1.3 City C

City C represents the two major Canadian cities with a population greater than one million inhabitants, namely:

Montreal..........	2.44	million	1966	population
Toronto	2.16	"	"	"

In Table 10t2, it will be observed that we take 2.3 cities of the City C type with a total population of 4.6 million, so that a rounded population of 2 million may be used with some consideration also to the fact that Vancouver is intermediate in size between City B and City C.

This largest generalized city has a very well developed arterial street system and a well developed freeway

system, serving principally the suburbs and the fringe area beyond the suburbs. Note from Table 10t1, that the per capita expenditures on motor vehicle operation are less than in City A or B. This is probably directly attributable to the increased expenditures on urban transit, because City C has a well developed, separate right-of-way, mass transit system, in addition to a well developed bus transit system operating in the streets. City C has a large well developed dense central district, with an area of 24.3 square miles and an average population density of 35,500 people per square mile. Largely because of the central core density, the overall density of City C is 9,300 people per square mile, which is higher than either of the other generalized cites. The density of the zone between the central district and the suburbs is much the same in City C as it is in Cities A and B. The suburbs themselves have low densities, intermediate between City A and City B.

The present per capita income in City C is $2,050 per year. Approximately 17% of this income is used for shelter and 30% for urban transportation. Further details of the population, transport, income and expense characteristics of City C are shown on Tables 10t1 and 10t2. Drawing C-10 shows the outline of zones and the transport network for analysis.

TABLE 10t1

CHARACTERISTICS OF GENERALIZED CITIES IN 1966

	CITY A 125,000 METRO INHABITANTS					CITY B 500,000 METRO INHABITANTS					CITY C 2,000,000 METRO INHABITANTS				
	URBANIZED AREA *				METRO AREA	URBANIZED AREA				METRO AREA	URBANIZED AREA				METRO AREA
	CENTRAL	CITY	SUBURBS	TOTAL		CENTRAL	CITY	SUBURBS	TOTAL		CENTRAL	CITY	SUBURBS	TOTAL	
POPULATION DENSITY RANGES in Persons Per Square Mile (gross)	Over 20,000	10,000 to 20,000	1,000 to 10,000	Over 1,000		Over 20,000	10,000 to 20,000	1,000 to 10,000	Over 1,000		Over 20,000	10,000 to 20,000	1,000 to 10,000	Over 1,000	
URBAN STRUCTURE															
Average Population Density - Persons per square mile	–	11,500	3,400	3,750		25,000	13,500	4,750	6,600		35,500	13,500	4,300	9,300	
Urbanized Area in square miles	–	1.4	29.2	30.6		2.2	9.7	55.5	67.4		24.3	27.5	150.9	203	
Single Family Dwellings * (number)	–	2,700	19,500	22,200		7,350	22,900	53,700	83,950		26,750	39,700	103,750	170,200	
Multiple Family Dwellings * (number)	–	2,100	7,000	9,100		8,500	13,300	15,400	37,200		206,850	62,450	60,450	329,750	
Dwelling Units With Cars * (number)	–	3,250	20,600	23,850		8,400	23,800	52,150	84,350		109,400	69,450	132,800	311,650	
TRANSPORT															
Autos per Capita				.327					.278					.290	
Person Trips per Capita per day by Transit				0.20					0.27					0.42	
Person Trips per Capita per day by Auto				1.73					1.59					1.07	
Arterial Grade Street Miles per 100,000 persons				51	78				33	59				22	37
Freeway Miles per 100,000 persons				1.1	5.4				1.0	3.3				2.4	4.0
Average auto trip length					2.7					4.5					9.0
Average transit trip length					2.2					2.7					5.8
Average Commercial vehicle trip length					2.7					4.4					7.9

* "Urbanized Area" is that with a population density of over 1,000 per square mile and "Metropolitan Area" is the larger zone defined by the limits of the political units which are part of the metropolitan region.

– See Table 13t9 for similar information for 2001.

TABLE 10t2

GENERALIZED CITIES IN 1966

PER CAPITA INCOME AND EXPENSE

	CITY A METRO AREA (1) 125,000 INHABITANTS		CITY B METRO AREA 500,000 INHABITANTS		CITY C METRO AREA 2,000,000 INHABITANTS		CANADA NATIONAL URBAN
	$ per yr.	%	$ per yr.	%	$ per yr.	%	$ per yr.
Income (salaries & wages)	1,950	100	2,000	100	2,050	100	
Fuel, Light, Water	60		51		59		61
Other shelter	210		235		282		262
TOTAL SHELTER EXPENSE (6)	270	14	286	14	341	17	323
Auto purchase	105		102		114		
Auto operation	101		110		96		
Urban transit	12		12		20		
Other urban travel (2)	8		6		9		
TOTAL PERSON (4) TRANSPORT EXPENSE	226	12	230	12	239	12	234
For Hire Trucking							208
Private Trucking							31
Moving & Storage Household Goods							3
TOTAL GOODS TRANSPORT COSTS (5)	123	6	173	9	371	18	242
ACCESS ROADS	15		15		15		15
TOTAL URBAN TRANSPORT (3)	364	19	418	21	625	30	491

TES TO TABLE 10t2

1) See Table 10t1 for definition of "Metropolitan Area".

2) Other urban travel includes the capital and operation costs of taxis, rented cars, motorcycles and scooters.

3) "TOTAL URBAN TRANSPORT" excludes inter-city transport although part of urban income is used for inter-city travel. Household and personal expenses also include a substantial inter-city transport element because of the inter-city transport cost component in the cost of manufactured goods.

Total urban transport also excludes the following: tow trucks, ambulances, service vehicles such as for hydro and telephone repair, farm tractors, construction equipment and government owned vehicles.

4) Person transport costs are based on the DBS 1964 Survey of Urban Family Expenditures (62-527) and the N. D. Lea & Associates Ltd., 11 City Study. The 1964 data were updated to 1966 by applying an increase of 17.5% derived from the 1968/69 Financial Post Survey of Markets.

5) The estimate of total goods transport costs is derived from DBS 53-222 and 53-207 as follows: Private urban trucking mileage is expanded from 2.5 billion in 1964 to 2.7 in 1966 and at $1 per vehicle mile gives $2.7 billions. For hire trucking is estimated at $0.4 billions applying some judgement to the conflicting figures and estimating about 50% urban. A population of 13 millions is used to give the national per capita figure. This includes villages down to about 4,000. Smaller places are considered to have little "urban" trucking. Goods transport costs are distributed between cities in the same proportion as found in the computer simulation.

6) Shelter expense information from DBS Survey of Family Expenditures.

7) See Table 13t5 for similar information for 2001.

10.1.4 Expense Distribution

Some comment is in order concerning the expense distribution shown on Table 10t2. The urban goods transport costs shown as 6% and 9% and 18% of income for cities A, B, C, respectively. This does not mean that the inhabitants of City C spent 18% of their income directly on urban goods movements. Rather, it means that the total urban goods movements costs for goods moved in City C is 18% of the income of inhabitants of City C. Some of this expense may become part of the cost of manufactured articles which are purchased and paid for by users in the rest of the nation. Conversely, the inhabitants of City A may indirectly spend more than 6% of their income on urban goods movements. Inter-city goods movements costs, if they were allocated reasonably to end consumers, would show as a greater proportion of the income of City A inhabitants than of City C inhabitants. For these two reasons, although Table 10t2 is believed to show a true distribution of total per capita goods costs by City type, it may be considered to distort, or show incompletely, the distribution of goods transport cost as a percentage of income.

10.2 NATIONAL POPULATION AGGREGATES 1966-2001

Table 10t3 summarizes the national population aggregates for the years 1966 and 2001. The method of developing the statistics for the year 1966 have been outlined in Section 10.1 and indicated on tables 2t3 and 2t4.

The forecasts of the populations for the year 2001 have been developed by a combination of procedures. First, the overall population of the nation, and the split into urban and rural, are derived from several basic reference sources*. Then the cities, namely City A, B and C, are based upon population projections for several real cities corresponding to each representative one. Thus, the number of cities of each type in 2001 is the same as in 1966. But the average population has increased by factors of 2.32, 2.44 and 2.83.

A small error is introduced because no allowance has been made for an increased number of cities of Type A. In fact, the benefits which may be achieved through

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* These sources include references (41), (42) and (43).

efficiency in Type A cities, will be principally in the larger cities of Type A. Therefore, the ommission of the newer and smaller cities of Type A in the year 2001 creates a very slight under-counting of the benefits. These new small type A cities are included in the rural population in 2001, which is, thereby, somewhat inflated.

If major new cities were created, as a result of major policy changes being imposed, rather than the natural growth trends being allowed to occur, then a condition different from that which is being analyzed in this report would be created.

10.3 NATIONAL INCOME AND EXPENSE AGGREGATES 1966

For the 12 million urban population of Canada in 1966, income and selected expense items are estimated as follows:

- The total income from salaries and wages is \$2,000 per capita for a total of \$24 billion.
- It is estimated that the expenditures on car purchases and car operations increased 17.5% from those given in the D.B.S. survey of family expenditures (19), chiefly as a result of price increases between 1964 and 1966. This resulted in the following estimated expenditures:
    - for automobile purchases: \$100 per capita for a total of \$1.2 billion,
    - for car operations: \$93 per capita for a total of \$1.1 billion,
- From the N. D. Lea 11 City Study urban transit expenses are estimated at \$15 per capita for a total of \$180 million,
- Other person transport expenses are estimated at \$8 per capita for a total of \$96 million,
- The total expenses for urban transport of people are estimated at \$216 per capita for a total of \$2.6 billion.

The costs of transporting goods have been divided into several items as described in Table 10t2.

- Common and contract carriers revenue is about \$400 million,

TABLE 10t3

CANADIAN POPULATION DISTRIBUTION BY CITY SIZE

1966 CENSUS			ESTIMATES BY GENERALIZED CITY TYPES							
			YEAR 1966				YEAR 2001			
Population range per city (000)	No. of cities	Total Pop. (000)	City Type	Pop. per city (000)	No. of cities	Population (000)	City Type	Pop. per city (000)	Est. % increase	Total Pop. (000)
Rural		7,335	Rural			7,930	Rural		12%	9,000
5-10	83	595								
10-25	71	1,120					A			
25-50	23	722	A	125	32.0	4,000		290	132%	9,300
50-100	5	608								
100-300	10	1,550								
300-1000	7	3,490	B	500	7.0	3,490	B	1,220	144%	8,500
1000 & Over	2	4,595	C	2,000	2.3	4,595	C	5,650	183%	13,200
Total		20,015				20,015			100%	40,000

- private urban trucking revenue as described also in the footnotes to Table 10t2 is a total expense of $2.7 billion,

- an allowance of $3 per capita for moving and storage of household goods amounts to $36 million.

- the total expense is, thus, about $3.1 billion.

Since the fuel and licensing fees for motor vehicles are about equivalent in total to the public expense for the construction and maintenance of roads, the assumption is made that the above costs include the costs of highways and roads and that no additional provision needs to be made for this purpose. Local access streets are paid for in a different fashion. These and a few miscellaneous items (notably the expenditures by public agencies on urban transport) require the addition of a further:

- Approximately $15 per capita for a total of $180 million.

The result is an estimated total urban transport expense in 1966 of approximately $5.9 billion, which, for 12 million people, is $491 per capita.

CHAPTER 11

ANALYTICAL APPROACH

This chapter describes the analytical approach which was developed for the project. The object of the analysis is to quantify the social and economic indicators, established in Chapters 8 and 9, and to do so for each condition requiring testing as a potential efficiency improvement. The analysis inputs and results are discussed in general terms in this chapter, but are presented in more detail in Chapters 12 and 13.

The section headings are:

11.1 NEUTRAL PATH

It is not possible to make a meaningful absolute evaluation of efficiency, but only of changes in efficiency, or of efficiency with respect to some base condition. Therefore, an important first step is the selection of the base condition or the neutral path, against which benefits or improvements will be measured. We prefer the term 'neutral path' because it is not a one-point-in-time condition, but rather a path into the future which may be considered 'neutral' because departures from it are evaluated as benefits or disbenefits. The neutral path has been referred to by Ramsey, Phelps & McKenzie as the "Golden Path".

For urban transportation the present conditions are one of the principal determinants of the near future.

The large urban investments in buildings and facilities create substantial resistance to any change. These existing conditions, therefore, enter the analysis as an exogenous and very important element which remains a common fixed point both on the neutral path and as the present condition for any of the schemes which are analyzed as deviations from this path.

In order to define a neutral path all of the significant variables or elements must be defined throughout the time series. For this project, the time series is defined at two points, namely, the present 1966 and the year 2001.

11.2 TIME SERIES - CAPITAL CHARGE

The rational evaluation of costs and benefits or disbenefits, requires the evaluation of time streams of money, some of which are comparatively constant from year to year, such as, for example, road maintenance costs, whereas others of which are very lumpy, as for instance, capital investment. There are two methods of comparing time streams:

- conversion to present worths or
- conversion to annual charges.

For this project we have selected the annual charge method with the end of the period - year 2001 - being the year for which the comparison is made. This requires that all capital costs be converted to annual charges.

It is characteristic of all capital investments that the investment is made at one point in time. The benefit stream begins at that point and continues into the future for the lifetime of the investment. This is in contrast with maintenance and operating expenses where the benefits are received in the same year the expense is incurred. Capital investments in transport facilities usually have rather long useful lives. For various purposes lives varying between 20 and 100 years are used. The following table illustrates the effect, upon the annual charge for capital, or various assumptions of useful life:

TABLE 11t1

CAPITAL RECOVERY FACTORS

LIFE	ANNUAL CAPITAL CHARGE COVERING DEPRECIATION AND INTEREST (Capital Recovery Factor)		
	8% Interest	9% Interest	10% Interest
10	.149	.156	.163
20	.102	.110	.117
30	.089	.097	.106
40	.084	.093	.102
50	.082	.091	.101
60	.081	.091	.100
100	.080	.090	.100

In Canada the opportunity cost of capital is not less than 8% to 9%, excluding inflation, and the average life of transport works is probably more than 20 years. Thus, a capital recovery factor of 10% is a reasonable assumption.

Since the period being considered is 35 years, which is similar to the life of capital investments, and since the annual rate of capital investment will generally increase with time, it is adequate to use a capital recovery charge in the last year of the period (2001) which is 10% of the capital invested during the period 1966 to 2001. The reason for such

a long period and the reason for making comparisons in the end year, is that we wish to take a long range view without being too constrained by the mistakes of the past. The existing conditions are, of course, a real constraint upon implementation and are fully considered as such.

The general assumption is made that the time streams of operating cost, maintenance cost, and benefits, all have a shape similar to the traffic growth curve. This is a logarithmic curve with a per capita growth rate of about 2.0% per year compounded annually. This assumption is reasonable because all of these costs are responsive to the traffic volume. On the basis of this assumption, the end year condition (2001) may be analyzed as representative of the whole period and the three quartiles will be as follows:

		% of End Year
Beginning of Period	1966	51
1st quartile	1975	61
2nd quartile	1984	73
3rd quartile	1993	87
End of Period	2001	100

Throughout the evaluation, significant departures from this assumption will be identified where they occur.

11.3 INPUTS

Table 11t2 gives a summary of the analysis inputs and outputs as the analysis was conceived in principal. The table indicates how each element is used in the analysis and how it is determined for 2001 conditions both on the neutral path and for variations from it.

The input elements are as follows:

11.3.1 Population

Population is an input to the analysis. It is determined by the usual trend-based projections for the

neutral path and is considered to be unchanged for deviations from the neutral path. The forecast of 2001 populations for the three generalized cities is described in Chapter 10. It is acceptable to treat population as exogenous because the overall growth and development of society and the present conditions appear to be the dominant elements in determining future population. The variation in population as a result of variations in other elements, such as the character of the transport system, is believed to be small.

11.3.2 Personal Income

As described in Section 8.2, a distinction is made between monetary and real income. Savings which may be achieved in the cost of transportation are, in effect, a price decrease which increases real personal income. Therefore, the monetary personal income enters the analysis as an input, which is treated the same way as population. It is determined for the neutral path by trend analysis and is considered to be unchanged for any deviations from the neutral path. For 2001 the average per capita income is $2,000 x 100/51 = $3,920.

The change in real income is quantified in monetary terms as the economic indicator of efficiency changes in the transport system. For the neutral path, the real income is assumed to be the same as the monetary income. For deviations from the neutral path, however, the increases in real income are calculated as the savings in transport costs (see section 8.2).

11.3.3 Land Use Patterns

Theoretically the most accurate method of forecasting the total future urban situation is by dynamic interaction between a land use model and a transport model. This method has not been used in this project for two reasons:

- firstly, because suitable, proven models are not available to do such dynamic simulation in a practical period of time (see Appendix B) and;

- secondly, because, even if proven models were available, they would not give the proper quantification of the variation in real personal income, which is the indicator that we wish to quantify in this analysis. Instead,

TABLE 11t2

SUMMARY DESCRIPTION OF ANALYSIS METHODOLOGY

ELEMENT, CONDITION OR VARIABLE		USED AS	HOW 2001 CONDITION DETERMINED: Neutral Path	HOW 2001 CONDITION DETERMINED: Deviations from Neutral Path
1. Population (total only) (see 4 for distribution)		Input	Trends-Judgement	No change
2. Personal Income	(a) Monetary	Input	Trends-Judgement	No change
	(b) Real	Output	Same as 2(a)	2(a) modified by 6
3. Transport Patterns (Decisions by Shippers and Travellers)		Endogenous	By transport model	By transport model
4. Land Use Patterns (Location Decisions concerning residential and other users).	(a) Metropolitan and Core Density	Input Constant	As in 1966	No change
	(b) Grain (i.e. distribution)	Input	As in 1966	Variable
5. Governmental Decisions (a) Transport Policy Rates Regulations, etc. (b) Transport Capital Investment in Facilities		Input	Judgement as most likely	Variable
6. Transport Demand		Input	Trends Judgement	No change
7. Transport Facilities		Input	Trends Judgement	Variable
8. Transport Cost		Endogenous	By model	By model
9. Social Indicators		Output	By model	By model

> they would simulate the actual consumer decisions to use the increased transport efficiency to buy more travel. They would, thus, disguise the efficiency improvements.

Therefore, although land use models which will simulate residential,commercial and industrial location decisions have been studies, as shown in Appendix B, the decision has been taken not to use such models for this project.

(a) Metro and Core Densities

The policy of treating the overall metropolitan density,that is, the dormitory density, and the core dormitory density also, as an exogenous constant, is established in the terms of reference of the project. In making this assumption, we do not imply that densities will, in fact, be unaffected by transport decisions. Indeed, Appendix A explores the relationship between transport and various welfare items, including location. The decision to hold overall density constant is necessary as the most practical method of calculating the variations of efficiency in terms of real income, as a result of variations in government decisions regarding transport.

The necessity of this assumption is illustrated by considering the effect of an alternative assumption:

> " for the neutral path and for each deviation from from the neutral path, the real life location decisions are simulated by some super land use model".

If this assumption were used to evaluate, for example, the effect of constructing a network of super highways which permit uncongested traffic to travel at 100 miles per hour, then consider the result. Because of the improved transport system some people would move farther away from the city centre, thereby increasing the size of the city, decreasing the overall density, and increasing the amount and the cost of the travel. The people who move and incur greater travel expense move only because they consider that they are bettering themselves. This means that they gain benefits through lower density living, which they value more highly than the additional cost they incur through more travel. This increased travel cost, therefore, is not a dis-benefit. Rather, it signals the presence of a benefit. In the calculation of total travel cost, however, it is positive, which is the same sign as the dis-benefits in the system, for example, the dis-benefit of increased congestion.

Therefore, the super-land-use-model method of analysis adds numerically benefits and dis-benefits and gives unacceptable results.

In order to avoid this problem, it is necessary to consider that overall density remains constant irrespective of the transport systems supplied.

(b) Grain

While holding the overall population density and land use mix constant, it is still possible to have significant internal variation in activity distribution, density pattern or grain. Within a large zone, for example, uniform pockets, in the patchwork quilt of land use, can vary in size from one lot to one square mile. For the neutral path the 2001 grain is held as in 1966, but one of the variations listed is variation in grain.

11.3.4 Governmental Decisions

Governmental decisions are the major independent variable which is introduced exogenously to the analysis. The neutral path is the set of governmental decisions considered to be most likely. For deviations from the neutral path, a variety of combinations of possible governmental decisions concerning such matters as pricing, new technology application, pattern and spacing of roads, transit operations, and the like are assumed and tested.

11.3.5 Transport Demand

Transport demand is expressed in terms of a series of origin-destination matrices which are developed by trend analysis for the neutral path, using the input land use information. Transport demand is held constant for all variations from the neutral path.

11.3.6 Transport Facilities

The anticipated neutral path network of transport facilities is the present network plus the additions which can be anticipated in the next 35 years as a result of a continuation of current investment policies and practices. This is one item on which variations from the neutral path are tested.

11.4 OUTPUTS

11.4.1 Transport Patterns

In real life, land use patterns and transport patterns are in dynamic inter-action. Transport models simulate the transport decisions of shippers and travellers which are dependent upon land use. Land use models simulate location decisions which depend upon transport patterns and facilities.

For this project, as described in Section 11.3.3, the land use is an input. A transport model may, therefore, be used to calculate the transport flow and patterns based upon the given land use and transport demand information. The transport flows are also dependent upon transport facilities and governmental policies and, therefore, they will need to be calculated by the model for each set of conditions.

Transport flows as such are not a directly useful output, but they are developed endogenously and used to calculate the meaningful economic and social indicators.

11.4.2 Economic Indicators

Total transport cost is the principal output which is required of the transport model for calculation of the principal economic indicator increase in real income. All elements of cost must be included: capital, maintenance and operating for the ways and the vehicles for all modes. Costs are brought to annual charges for 2001 as explained in section 11.2.

11.4.3 Social Indicators

Time, accessibility and survival are the selected social indicators, as discussed in Chapter 9. These would ideally be direct output from a transport model. This has been practical only in the case of unpaid time and accessibility. Estimates have been required for life expectancy.

11.5 MODEL SELECTION AND FUNCTION

Appendix D describes in some detail how the TRANS model has been selected and modified for use on this project. TRANS, as modified for this project, accepts the grographic and demographic input information, calculates traffic flows and then calculates transport costs and times.

The model was first run for 1966 conditions for calibration purposes. Then four runs were made for 2001 conditions as described in section 11.7.

It should be made clear that although the TRANS model runs were the backbone of the analytical work, they are really only one part of the analysis. Many substantial subsidiary analyses were carried out, both manually and by computer, on particular outputs of the project. The most useful function of the TRANS analysis was probably in the supply of a great deal of detailled information about the neutral path which was, thereafter, available for innumerable subsidiary analyses.

11.6 MODEL CALIBRATION AND CHECKS

The TRANS model was run for the three present generalized cities and some calibration adjustments were made in consideration of traffic flow information from actual cities.

The cost outputs were checked against DBS data. Table 11t3 shows the comparison between transport cost estimates derived from DBS data and the estimates obtained from the TRANS model:

TABLE 11t3

ANNUAL PER CAPITA URBAN TRANSPORT COSTS

in dollars (1966)

	PRESENT CITY A		PRESENT CITY B		PRESENT CITY C		NATIONAL AVERAGE	
	DBS	TRANS	DBS	TRANS	DBS	TRANS	DBS	TRANS
Persons Transport	226	211	230	228	239	301	234	254
Goods Transport	123	144	173	203	371	435	242	284
TOTAL TRANSPORT	349	355	403	431	610	736	476	538

NOTE: DBS data is from table 10t2 and TRANS data is from the computer printouts.

It is evident that there is reasonably good agreement between the DBS data and the TRANS results. TRANS costs tend to be higher, particularly for City C and for goods. It is suggested that this difference is due mostly to the fact that the DBS data does not include the costs of either government owned trucks or service trucks, which, especially in the larger urban areas, comprise a significant proportion of the total non-passenger vehicle transport.

Another check was made on average trip lengths. The TRANS results for the neutral path are as follows:

TABLE 11t4

AVERAGE TRIP LENGTHS IN MILES

	1966			2001		
	CITY A	CITY B	CITY C	CITY A	CITY B	CITY C
Auto	2.7	4.5	9.0	3.6	6.0	12.0
Transit	2.2	2.7	6.8	2.5	3.1	7.8
Truck	2.7	4.4	7.9	3.5	5.9	10.5

The average calculated trip lengths as shown on Table 11t4 for 1966 were compared with empirical data. The agreement was within 10%. The future trip lengths for City C were thought to be rather high but on careful checking with work in both Toronto and Chicago, we have concluded that they are in reasonable accord with the best currently available information.

11.7 MODEL RUNS

The TRANS model as calibrated for this project was run four times for 2001 conditions. Table 11t5 gives an outline description of these four runs and of how each of the main transport system elements was treated in each of the four runs.

This Table 11t5 identifies the major transport system elements which are the items that we change in seeking to improve efficiency. For each of these elements, the table indicates:

- how the 2001 neutral path condition was determined.
- the procedures followed in selecting the 2001 characteristics. Whether this be by trend or sub-study is shown by Column 2 or 3.
- for each model run whether each element was input in its neutral path or optimized condition.
- for each condition, how the social and economic indicators were calculated, whether through model run or sub-study.

TABLE 11t5

SUMMARY OF MODEL RUNS AND SUB-STUDIES

TRANSPORTATION SYSTEM ELEMENTS	TREND	SUB-STUDY	MODEL RUN NUMBER 1	2	3	4	DESCRIPTION OF THE NEUTRAL PATH
ACCESS ROADS							Present conditions prevail
Optimization		0*					
Neutral Path	0		i	i	i	i	
ARTERIALS & FREEWAYS							Additions recommended for 1980s are achieved by 2001
Optimization		0		*			
Neutral Path	0		*		i	i	
TRAFFIC OPERATIONS							Present trends are followed
Optimization		0*			*		
Neutral Path	0		*	i		i	
TRANSIT OPERATIONS							Per capita transit trips are unchanged
Optimization		0*					
Neutral Path	0		*	i	i	i	
GRAIN							There will be no change in grain from existing conditions
Coarse (concentration)		0*					
Fine (scatterization)		0			*		
Neutral Path	0		*	i		i	
TRUCKING							Present trends are followed
Optimization		0*					
Neutral Path	0		*	i	i	i	
PRICING							Assume present practices are followed
Optimization		0*					
Neutral Path	0		*	i	i	i	
NEW TECHNOLOGY							No new technology
Improved bus - optimum		0*					
Moving sidewalk- optimum		0*					
Programmed modules-optimum		0				*	
Neutral Path			i	i	i		
CORRIDORS							As present No corridors
Optimization		0*					
Neutral Path			i	i	i	i	

LEGEND

i - the inputs to the model runs were for the condition described on the left.

0 - characteristics describing this condition of the element were selected by method shown at head of column.

* - social and economic indicators were calculated by the method shown at the head of the column.

Run #1

Run #1 was for all three Cities A, B and C and was made to define the 2001 neutral path condition, i.e., the condition against which changes would be measured.

Run #2

Run #2 was for the condition of optimum arterial and freeway spacing which condition was determined by a major subsidiary analysis.

Run #2 was for City B only. The same proportionate changes were subsequently applied to Cities A and C.

Run #3

Run #3 quantified the effects of both fine grain and optimum traffic operations. Run #3 was for City B only.

Run #4

Run #4 qualified the effects of an optimum programmed module system in City B.

CHAPTER 12

ANALYSIS INPUTS

This chapter discusses and presents the detailled input data which was used for the analysis. The sectional headings are:

12.1 LAND USE PATTERNS (Population & Employment)

12.2 TRANSPORTATION FACILITIES

12.3 TRANSPORT DEMAND (Trip Generation)

12.4 COSTING

12.5 OPTIMUM CONDITIONS

12.1 LAND USE PATTERNS (Population & Employment)

The topographic features of the three generalized cities are shown on drawings A10, B10 and C10. These were derived by an amalgamation of topographic features of real Canadian cities. The analytical zones are also shown on drawings A10, B10 and C10.

The land use patterns can most easily be quantified as population and employment statistics by zone. This is done on tables Et1, Et2 and Et3 (Appendix E), for present (1966) conditions. These statistics were developed to represent present conditions in real Canadian cities.

For the future, as discussed in section 11.3.3, there will be no change in the overall city density and in the overall land use mix and in the Central Business District density. This is illustrated by the sketch shown below:

FIGURE 12f1

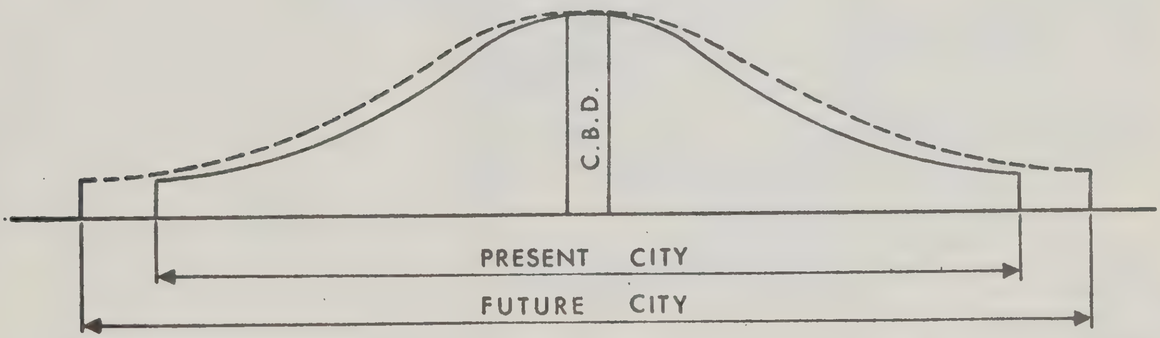


DIAGRAM OF DENSITY VARIATIONS

Thus, any particular zone will increase in density, depending on its distance from the CBD, but the mix of land use in the zone will remain similar to the present. Peripheral analysis zones are made sufficiently large to contain the boundary of the urbanized region both in 1966 and in 2001. The resulting new populations and employments by zone for 2001 are shown on tables Et4, Et5 and Et6 (Appendix E).

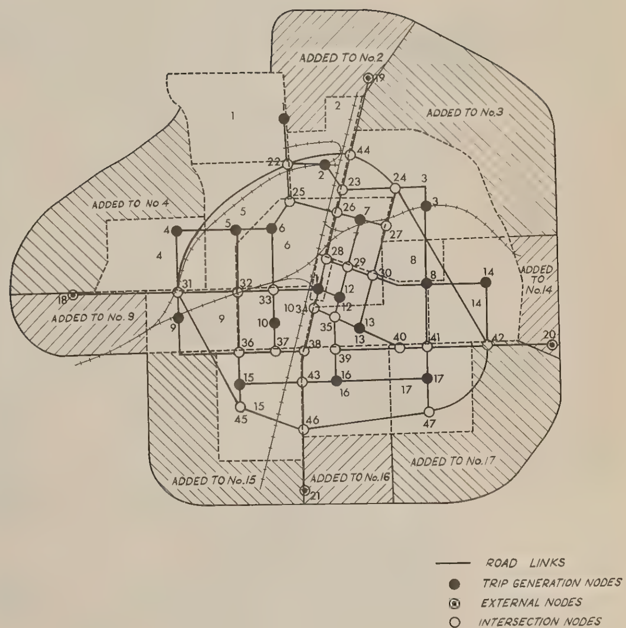
A summary of the characteristics of the generalized cities is shown on table 10t1 for 1966 conditions and on table 13t4 for 2001 conditions.

12.2 TRANSPORT FACILITIES

The transport facilities of the generalized cities are shown in red on drawings A10, B10 and C10, in terms of link-node networks. The drawings show both existing and proposed future facilities for each city. The characteristics of each transport link are described in Tables Et7, Et8 and Et9.

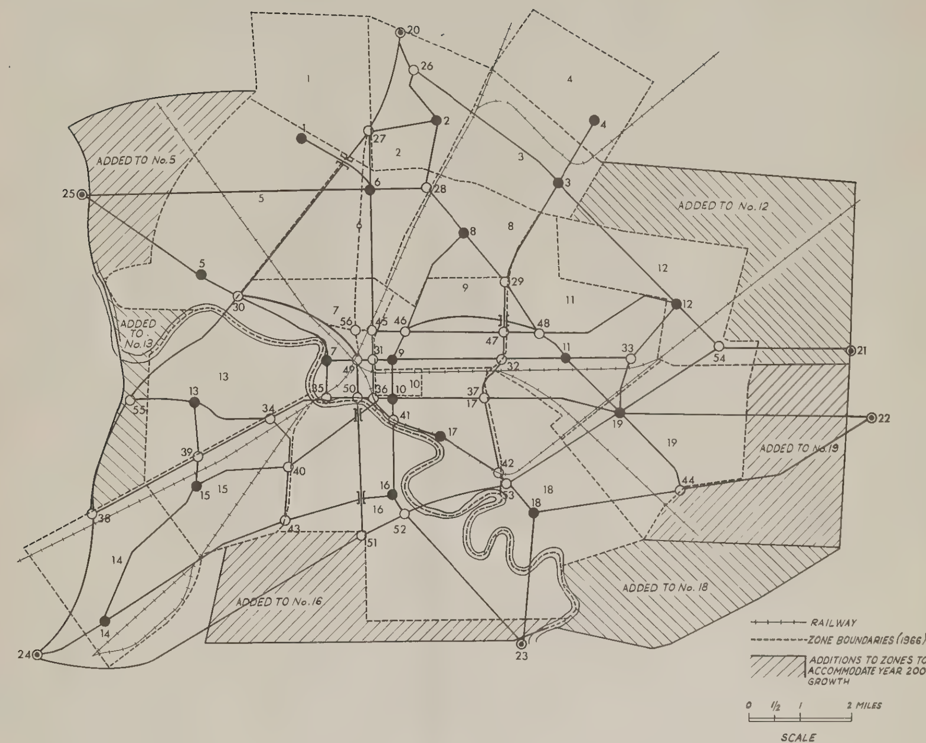
For City B, networks were defined for four alternative year 2001 configurations: (a) Neutral Path, (b) Fine Grain & Optimized Traffic Operations, (c) Programmed Module Transit System, and (d) Optimized Arterial and Freeway Spacing, which required a number of extra facilities. The detailled characteristics of these links are shown on table Et8.

For cities A and C a future (Neutral Path) network was drawn up, but only functional classifications (arterial or freeway) were defined since detailled model runs were not performed for these 2001 cities.



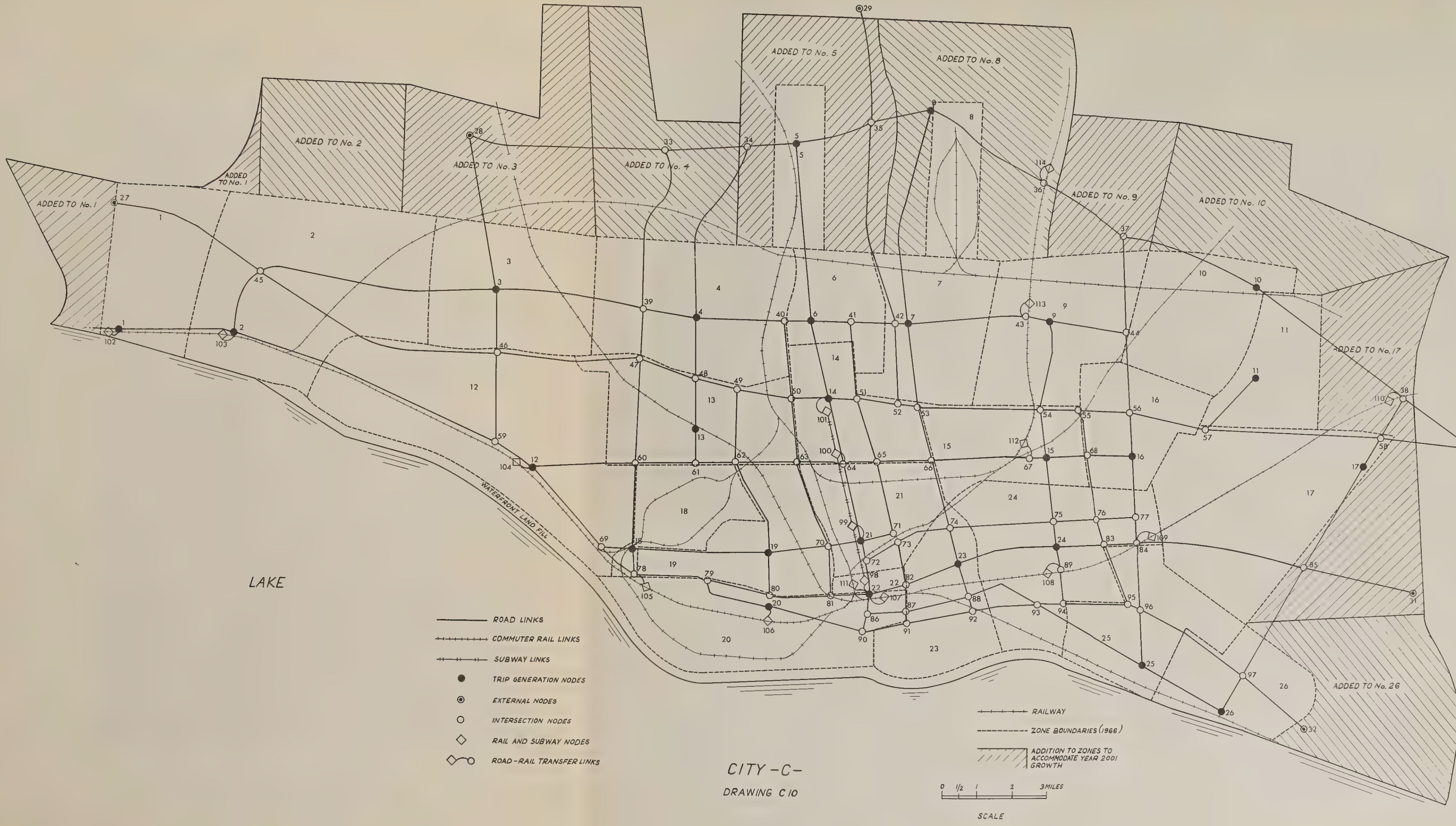
CITY —A—

DRAWING A10



CITY —B—

DRAWING B10



CITY -C-

DRAWING C 10

12.3 TRANSPORT DEMAND (Trip Generation)

Trip generations and attractions were related to the demographic data by zone, i.e., to population and employment. The resulting traffic flows were calibrated against present conditions.

The steps followed in estimating 1966 trip ends were briefly as follows:

(a) Person Trips

1. Estimate 24 hour total trip generation by zone.
2. Split to peak and off-peak.
3. Apportion by work and non-work purposes for peak and off-peak.
4. Allocate to auto and transit modes for peak and off-peak.
5. Estimate external trips and allocate to external zones in proportion to auto trip counts on connecting road links.

(b) Truck Trips

1. Estimate total truck trips by zone.
2. Allocate to residential land on basis of population; to commercial, industrial and other land uses on basis of employment.
3. Split to peak and off-peak.
4. Split by light and heavy trucks and convert to tons of goods.
5. Estimate external trips and allocate to external zones in proportion to truck counts on connecting road links.

The relationships used to make these calculations were derived from observed data obtained from various sources in Canada and the U.S.A. The present trip productions and attractions were developed by "commodity". Tables Et10 and Et11 illustrate this information for City A. The values shown in these tables represent half-day trips. To simplify data processing, only one direction of each trip was simulated, and it was assumed that over a 24-hour period, each such trip would be matched by a return trip in the opposite direction. Thus, the calculated measures of system time, cost, etc., were doubled, to obtain an estimate for the whole day.

The "commodities" were distributed using a simple gravity model formulation with an empirically derived travel factor function, then assigned to the transport network so as to minimize origin-destination perceived costs.

12.4 COSTING

Throughout this report, all costs are expressed in 1969 dollars. Prices, including crew wages, are considered to remain unchanged from 1966.

Vehicle operating costs are divided into three components:

- crew wages
- fixed costs
- variable costs

For trucks and surface transit the crew wages are taken at $4.00 per hour. This rate applies to all hours but the time is separated into travel time, which is affected by speed, and pick-up-and-delivery time which is affected only by the efficiency of the P & D operation. Crew wages are taken as zero for autos.

Fixed costs are considered to be only terminal construction costs for trucking and transit. For auto, however, depreciation, insurance and licensing are considered fixed costs.

For variations from the neutral path certain cost elements are considered variable whereas others are fixed. In general, these have been adopted as follows:

For Trucking: - all vehicle operating costs including depreciation and overhead are variable; crew, depreciation and overhead costs are considered variable with operating truck hours and maintenance, fuel and tire costs are considered variable with truck miles.

For Transit: - vehicle depreciation and overhead costs are considered variable with the peak hour traffic volume carried; and crew, vehicle maintenance and operating costs variable with the vehicle miles.

For Auto: - depreciation, insurance and license are considered fixed except for possible major changes due to new technology. Maintenance, fuel and tire costs are considered variable with vehicle miles driven.

12.5 OPTIMUM CONDITIONS

For each variation proposed, the optimum conditions require some input changes. For example, optimizing the spacing of arterials and freeways requires a change in the transport network. This optimum condition input information is considered in Chapters 15 to 23.

CHAPTER 13

ANALYSIS RESULTS

This chapter presents in summary tabular form the results of the main analysis.

The following are the tables:

13t1	Year 2001 - TRANS Model Results for City A
13t2	Year 2001 - " " " " City B
13t3	Year 2001 - " " " " City C
13t4	Characteristics of Generalized Cities in 2001
13t5	Generalized cities 2001 per capita Income and Expense

Readers are reminded to review the assumptions (14p2) which accompany these findings, especially those relating to transport models (Appendix D, sections D.1.5 and D.4).

TABLE 13t1

RESULTS OF "TRANS" MODEL RUNS - CITY A

	1966	YEAR 2001 - INHABITANTS 290,000			
RUN NO. DESCRIPTION	0 PRESENT	1 NEUTRAL PATH	2 ROADS	3 GRAIN	4 MODULE
DAILY PERSON TRANSPORT COST					
a) Auto Variable	$17,000	$ 69,800	$ 69,000	$ 61,000	$ 59,000
b) Auto Fixed	$62,800	$186,500	$186,500	$186,500	$186,500
c) Transit Operating	$ 2,300	$ 8,400	$ 7,100	$ 6,300	$ 9,700
d) Transit Fixed	$ 250	$ 1,100	$ 1,100	$ 900	$ 5,200
DAILY GOODS TRANSPORT COST					
a) Operating	$31,900	$ 84,500	$ 77,800	$ 71,700	$ 70,300
b) Time	$22,800	$ 62,400	$ 44,500	$ 52,900	$ 51,000
c) Fixed	$ 1,600	$ 4,400	$ 3,200	$ 3,800	$ 3,600
DAILY UNPAID TIME (HRS.)	28,600	144,000	121,000	121,100	92,000
ACCESSIBILITY INDEX					
a) Auto Work	12,300	58,000	61,000	61,000	61,000
b) Auto Non-Work	26,400	126,500	132,000	132,000	132,000
c) Transit Work	10,500	23,200	27,900	27,600	61,000
d) Transit Non-Work	22,500	61,000	73,200	72,500	132,000
ACCESSIBILITY RATIO					
a) Auto Work	1.000	0.950	1.000	1.000	1.000
b) Auto Non-Work	1.000	0.960	1.000	1.000	1.000
c) Transit Work	0.853	0.380	0.456	0.451	1.000
d) Transit Non-Work	0.852	0.460	0.552	0.547	1.000

TABLE 13t2

RESULTS OF "TRANS" MODEL RUNS - City B

	1966	year 2001 - INHABITANTS 1,220,000			
RUN NO. DESCRIPTION	0 PRESENT	1 NEUTRAL PATH	2 ROADS	3 GRAIN	4 MODULE
DAILY PERSON TRANSPORT COST					
a) Auto Variable	$110,400	$475,000	$466,500	$349,200	$401,900
b) Auto Fixed	$216,000	$673,000	$673,000	$673,000	$673,000
c) Transit Operating	$ 27,400	$107,500	$ 89,200	$ 65,600	$123,310
c) Transit Fixed	$ 2,300	$ 10,600	$ 10,600	$ 8,600	$ 55,200
DAILY GOODS TRANSPORT COST					
a) Operating	$174,900	$483,000	$445,500	$343,200	$428,200
b) Time	$134,200	$384,000	$271,900	$291,000	$309,600
c) Fixed	$ 9,100	$ 26,300	$ 18,900	$ 20,200	$ 21,500
DAILY UNPAID TIME (HRS.)	194,600	1,038,400	862,000	737,700	659,500
ACCESSIBILITY INDEX					
a) Auto Work	155,300	682,900	762,200	819,000	854,900
b) Auto Non-Work	341,700	1,532,600	1,740,600	1,887,100	1,992,000
c) Transit Work	103,700	228,600	336,600	413,200	854,900
c) Transit Non-Work	219,600	597,100	808,100	956,500	1,992,000
ACCESSIBILITY RATIO					
a) Auto Work	0.890	.640	0.714	0.768	.800
b) Auto Non-Work	0.876	.641	0.728	0.790	.833
c) Transit Work	0.594	.214	0.315	0.388	.800
c) Transit Non-Work	0.563	.250	0.338	0.400	.833

TABLE 13t3

RESULTS OF "TRANS" MODEL RUNS - City C

	1966	Year 2001 - INHABITANTS 5,660,000			
RUN NO. DESCRIPTION	0 PRESENT	1 NEUTRAL PATH	2 ROADS	3 GRAIN	4 MODULE
DAILY PERSON TRANSPORT COST					
a) Auto Variable	$765,900	$3,835,000	$3,777,000	$3,124,000	$3,242,000
b) Auto Fixed	$904,000	$3,271,000	$3,271,000	$3,271,000	$3,271,000
c) Transit Operating	$168,700	$ 764,000	$ 636,000	$ 527,800	$ 879,000
d) Transit Fixed	$ 46,800	$ 265,000	$ 265,000	$ 230,000	$1,374,000
DAILY GOODS TRANSPORT COST					
a) Operating	$1,533,800	$5,290,000	$4,870,000	$4,179,000	$4,406,000
b) Time	$1,198,100	$3,960,000	$2,704,000	$3,167,000	$3,117,000
c) Fixed	$ 75,700	$ 272,000	$ 198,000	$ 225,000	$ 226,000
DAILY UNPAID TIME (HRS.)	2,185,100	14,342,000	11,950,000	11,342,000	9,162,000
ACCESSIBILITY INDEX					
a) Auto Work	2,161,900	11,350,000	13,700,000	14,300,000	16,470,000
b) Auto Non-Work	5,062,000	26,600,000	30,600,000	33,500,000	38,600,000
c) Transit Work	1,651,900	3,640,000	4,340,000	4,580,000	16,470,000
c) Transit Non-Work					
ACCESSIBILITY RATIO					
a) Auto Work	0.695	0.503	0.609	0.633	0.731
b) Auto Non-Work	0.710	0.514	0.591	0.648	0.745
c) Transit - Work	0.531	0.162	0.193	0.208	0.731
d) Transit Non-Work	0.566	0.213	0.254	0.268	0.745

TABLE 13t4

CHARACTERISTICS OF GENERALIZED CITIES IN 2001

	CITY A 290,000 METRO INHABITANTS					CITY B 1,220,000 METRO INHABITANTS					CITY C 5,660,000 METRO INHABITANTS				
	URBANIZED AREA				METRO AREA	URBANIZED AREA				METRO AREA	URBANIZED AREA				METRO AREA
	CENTRAL CITY		SUBURBS	TOTAL		CENTRAL	CITY	SUBURBS	TOTAL		CENTRAL CITY		SUBURBS	TOTAL	
POPULATION DENSITY RANGES In Persons Per Square Mile (gross)	Over 20,000	10,000 to 20,000	1,000 to 10,000	Over 1,000		Over 20,000	10,000 to 20,000	1,000 to 10,000	Over 1,000		Over 20,000	10,000 to 20,000	1,000 to 10,000	Over 1,000	
URBAN STRUCTURE															
Average Population Density - Persons per square mile	-	11,500	3,400	3,750		25,000	13,500	4,750	6,600		35,500	13,500	4,300	9,300	
Urbanized Area in square miles	-	3.2	67.7	70.9		5.4	23.7	135.4	164.5		68.8	77.8	427.0	573.6	
Single Family Dwellings * (number)	-	6,250	45,250	51,500		17,950	55,900	131,000	204,850		75,700	112,350	293,600	481,650	
Multiple Family Dwellings * (number)	-	4,850	16,250	21,100		20,750	32,450	37,550	90,750		585,400	176,750	171,050	933,200	
Dwelling Units with Cars * (number)	-	9,900	56,750	66,650		27,800	78,400	155,050	261,250		410,350	262,900	439,550	1,112,000	
TRANSPORT															
Person Trips per Capita per day by Transit				0.20					.27					.42	
Person Trips per Capita per day by Auto				2.10					1.93					1.45	
Arterial Grade Street Miles per 100,000 persons				23	37				14	25				8	15
Freeway Miles per 100,000 persons				5.6	9.7				2.0	3.6				2.0	3.4
Average auto trip length					3.6					6.0					12.0
Average transit trip length					2.5					3.1					7.8
Average Commercial vehicle trip length					3.5					5.9					10.5

NOTE: See Table 10t1 for similar information for 1966.

TABLE 13t5

GENERALIZED CITIES IN 2001

PER CAPITA INCOME AND EXPENSE

	CITY A METRO AREA 290,000 INHABITANTS	CITY B METRO AREA 1,220,000 INHABITANTS	CITY C METRO AREA 5,660,000 INHABITANTS
Income (salaries & wages)*	3,900	4,000	4,100
TOTAL SHELTER EXPENSE *	540	572	682
Auto purchase	206	177	185
Auto operation	77	124	217
Urban transit	10	31	58
Other urban travel *	16	12	18
TOTAL PERSON TRANSPORT EXPENSE	309	344	478
TOTAL GOODS TRANSPORT COST	167	235	538
ACCESS ROADS *	30	30	30
TOTAL URBAN TRANSPORT	506	609	1,046

Cities A and C expanded from present
in same ratio as City B

* From 1966 data using a growth rate of 2% per annum.

NOTE: - See Table 10t2 for similar information for 1966.

CHAPTER 14

SUMMARY OF METHODOLOGY AND ASSUMPTIONS

This chapter is intended to summarize briefly the methodology and project assumptions which are described in detail in Chapters 1 to 13.

	Reference Report Section
- Political and administrative issues are excluded	1.2.1
- Degree of goal achievement through transport is assessed by:	7.1
Economic Indicators:	
- income increase as indicated by transport cost savings	8.2
- income distribution and	8.3
Social Indicators:	
- unpaid travel time	9.2
- accessibility	9.3
- life expectancy	9.4
Secondary effects are recognized but not quantified	5.5.4, 7.7, 8.2.4 & 24.2
- All comparisons are made with the "neutral path" condition in year 2001	11.1 & 11.2
- Totals for Canada are simulated by the sum of:	10.3

32 A cities 125,000 population 1966 and 290,000 in 2001
7 B cities 500,000 population 1966 and 1,220,000 in 2001
2.3 C cities 2,000,000 population 1966 and 5,650,000 in 2001

- Path conditions which remain unchanged for variations from the neutral path include the following:

  - real per capita income growth 2% p.a. 1966 to 2001 — 2.3
  - gross dormer density unchanged 1966 to 2001 — 11.3.3
  - unpaid vehicle operator's time is zero cost — 9.2
  - 1969 dollars are used throughout
  - transport demand related to demographic data — 12.3
  - transport costs from current experience — 12.4

- Conditions which change for variations from the neutral path are discussed with findings. — 24

- "TRANS" model was calibrated for 1966 conditions and run 4 times to calculate 2001 indicators for: — 11.5 & 11.7

  - neutral path
  - optimized arterial and freeway spacing
  - fine grain and optimized traffic operations
  - programmed module system

- Indices for other conditions were determined by subsidiary analysis or estimates.

- For the Neutral Path situation, it was assumed that all freeways proposed for 1980 to 1986 in current plans will, in fact, be built.

CHAPTER 15

TRUCKING

The improvements attainable through trucking is the subject of a separate technical memorandum, which is briefly summarized in this chapter.

There is a dirth of reliable technical information concerning urban trucking and, therefore, substantial amounts of judgement have been necessary in arriving at an estimate of benefits.

Two methods have been identified for improving the efficiency of trucking, namely:

- consolidation of shipments, terminals, and trucking and
- improvement of shipping and receiving facilities.

Present urban pick-up-and-delivery operations employ many trucks with very light loads, duplicating one anothers stops and routes. There would appear to be substantial benefits through consolidation of shipments, terminals and trucking. All three are necessary for both private and for-hire operation in order to achieve substantial benefits. The major drawback is that consolidation can only, practically, be brought about through some type of regulation.

It has been estimated that, through consolidation, the amount of empty travel could be reduced by 50% for urban pick-up-and-delivery operations. The value of this saving has been calculated as 9.1% of vehicle operating costs and 6.4% of crew wages and fixed costs, giving a total potential benefit of $0.8 billion in 2001.

Another major source of urban trucking inefficiency is in time spent in pick-up-and-delivery stops. It is estimated that this consumes about 50% of total truck time and that approximately 30% of the pick-up-and-delivery stop time is unnecessary. Improvement may be achieved principally through providing better shipping-and-receiving facilities. The potential saving has been estimated at 10% of crew wages only, which amounts to about $0.4 billion per year by 2001. These benefits could be achieved principally through the construction of improved shipping-and-receiving facilities and the streamlining of the associated paper work.

The economic impact is thus substantial and, if it is assumed that benefits are passed on, then they will be widely distributed throughout society to all consumers of the goods transported.

Social effects will be in the direction of improvement but will be modest through consolidation which has only the necessary direct effect of reducing truck traffic and, therefore, reducing pollution and accidents. If regulation of the polluting effects of the goods vehicle is introduced, then through regulated trucking, a major improvement in urban noise may be achieved and also a significant improvement in air pollution.

A summary of the effects of more efficient trucking is given on the following table, 15t1.

TABLE 15t1

SUMMARY OF EFFECTS OF MORE EFFICIENT TRUCKING

DESCRIPTION OF IMPROVEMENTS			Consolidation of shipments, terminals and trucking.	Improve shipping-and-receiving facilities
NEUTRAL PATH CONDITION			Truck terminal quality and truck load factors remain as 1966.	Percentage of time for shipping and receiving remains as now.
APPROXIMATE CONFIDENCE LIMITS			- 50% + 75% to + 200%	- 50% + 75%
TIME STREAM	EARLIEST LIKELY YEAR FOR SIGNIFICANT BENEFITS		1985	1985
	AMOUNT OF 1985 BENEFITS AS % OF 2001		40	30
EXTRA CAPITAL INVESTMENT REQUIRED ($ BILLIONS TO 2001)			Nil - only normal replacement and expansion of terminals	Small - mostly normal replacement and expansion.
ECONOMIC EFFECTS	TRANSPORT COST SAVING	TOTAL NATIONAL IN 2001	$0.8 Billions	$0.4 Billions
		PER CAPITA INCOME IMPROVEMENT IN 2001	$26/cap/yr.	$13/cap/yr.
	DISTRIBUTION OF INCOME IMPROVEMENT		all consumers	all consumers
SOCIAL EFFECTS	SAVINGS OF UNPAID TIME IN 2001		nil	nil
	ACCESSIBILITY IMPROVEMENT		nil	nil
	LIFE EXPECTANCY INCREASE		slight	nil
	ENVIRONMENT		Although consolidation will modestly improve environment, a much more substantial environmental improvement is possible through trucking by improving vehicle designs so as to decrease noise and air pollution.	

CHAPTER 16

ARTERIALS AND FREEWAYS

This chapter is a brief summary of the separate technical memorandum on improvements attainable through arterials and freeways.

Improvement of the spacing and pattern of arterials and freeways is the most promising method which we have studied for increasing urban transport efficiency.

Subsidiary studies were carried out to determine the optimum spacing and pattern of arterials and facilities. These studies were in considerable depth, including the development of a new computer programme for carrying out, for Canadian conditions, a modified Black analysis, for determining optimum spacing. The very substantial savings were then quantified through computer runs which indicate both the economic benefits through cost savings and the social benefits through unpaid time savings.

The economic benefits amount to $1.8 Billions per year in 2001 from optimizing spacing and $0.4 Billions from improving pattern. The optimized spacing is a closer spacing which thus amounts to the same thing as building more arterials and freeways. A capital charge of 10% of the estimated extra capital investment from 1971 to 2001 has already been deducted from the gross benefits to obtain the net figure of $1.8 Billions. The pattern improvements can be achieved through better planning which eliminates discontinuities and achieves patterns closer to the ideal.

The benefits are expected only in the new areas of our cities, where it is possible to do better planning now in order to achieve, gradually, over the years, these forecast benefits, for optimum road spacing and pattern.

The economic benefits accrue largely through reduced trucking costs and are, therefore, distributed thorughout the communities to all consumers as the savings are passed on. Some economic benefits accrue to all auto and bus users.

The social benefits of time savings accrue to road users, both auto and bus. Improved freeways might result in some further switch to auto, however, which could be some disadvantage to the poorer sectors of society, unless at the same time suitable measures are instigated to overcome this disadvantage.

Safety and accessibility are substantially improved. The environmental effect through sight, smell and sound depends greatly upon the design of the facilities. If the facilities are well designed then the sight, sound and smell may be less of problems than they would be if the traffic were more conjested on fewer facilities.

The findings are summarized in the following table, 16t1.

Table 16t1

SUMMARY OF EFFECTS OF ARTERIAL AND FREEWAY IMPROVEMENTS

DESCRIPTION OF IMPROVEMENTS			Improve the spacing of freeways and arterial roads.	Improve arterial and freeway network pattern.
NEUTRAL PATH CONDITION			Current published master plans for 1980 to 1986 are assumed to be built by 2001.	Continue as at present - basically a rectangular grid.
APPROXIMATE CONFIDENCE LIMITS			- 40% + 80%	- 40% + 80%
TIME STREAM	EARLIEST LIKELY YEAR FOR SIGNIFICANT BENEFITS		1980	1980
	AMOUNT OF FIRST YEAR BENEFITS AS % OF 2001		10	10
EXTRA CAPITAL INVESTMENT REQUIRED TO 2001			$1.8 Billions	Very little if improvement made during planning.
ECONOMIC EFFECTS	TRANSPORT COST SAVING	TOTAL NATIONAL IN 2001	$1.8 Billions	$0.4 Billions
		PER CAPITA INCOME IMPROVEMENT IN 2001	$58/cap/yr.	$14/cap/yr.
	DISTRIBUTION OF INCOME IMPROVEMENT		very widely	very widely
SOCIAL EFFECTS	SAVINGS OF UNPAID TIME IN 2001		78 man hours /cap/yr.	24 man hours /cap/yr.
	ACCESSIBILITY IMPROVEMENT		substantial	some improvement
	LIFE EXPECTANCY INCREASE		some	slight
	ENVIRONMENT		sight, sound and smell are not necessarily affected but the mobility of the poor is likely to be decreased.	slight improvement

CHAPTER 17

ACCESS ROADS

The improvements attainable through access roads is the subject of a separate technical memorandum, which is summarized briefly in this chapter.

There is a tendency to build access roads or local streets at a higher standard, both with regard to geometry and pavement, than is necessary. The pattern of access roads also tends to make travel unnecessarily circuitous and to increase unnecessarily the amount of travel on some streets. The inefficient patterns are usually due to the history of the planning and sub-division process which often makes it difficult to avoid awkward discontinuities. The over-design of standards is usually due to the requirement of lending agencies or other regulatory bodies.

The adoption of only "adequate" standards for access roads is estimated to yield a maximum annual saving of $50 per capita, but, for various reasons, it is considered that only about half of this can be realized and, on this basis, about $0.5 billions of savings are considered possible by the year 2001.

Improved access road patterns are estimated to bring about an average trip length saving of 0.3 miles, which, applied to the variable portion of transport cost, results in an annual saving, in 2001, of $0.25 billions after a 25% reduction, because of institutional constraints.

These changes in the access roads bring about little change in social indicators, except that the reduction in the standard of construction in access roads may create a decrease in the neighbourhood aesthetic values.

The benefits are distributed to affected home owners in the case of reduced standards and to all who live in the communities affected by improved pattern. Transport for high density living cannot be significantly improved by these means.

The finding concerning access roads are summarized on table 17t1.

Table 17t1

SUMMARY OF EFFECTS OF CHANGED ACCESS ROADS

DESCRIPTION OF IMPROVEMENTS			Lower standards	Improved patterns
NEUTRAL PATH CONDITION			Current standards continued	Current practice continued
CONFIDENCE LIMITS			- 25% + 50%	- 50% - 0%
TIME STREAM	EARLIEST LIKELY YEAR FOR SIGNIFICANT BENEFITS		1980	1980
TIME STREAM	AMOUNT OF 1980 BENEFITS AS % OF 2001		10	10
EXTRA CAPITAL INVESTMENT REQUIRED			Negative, about $8 billion savings to 2001 which are included under "economic effects"	nil
ECONOMIC EFFECTS	TRANSPORT COST SAVING	TOTAL NATIONAL IN 2001	$0.5 Billions	$0.25 Billions
ECONOMIC EFFECTS	TRANSPORT COST SAVING	PER CAPITA INCOME IMPROVEMENT IN 2001	$15/cap/yr.	$8/cap/yr.
ECONOMIC EFFECTS	DISTRIBUTION OF INCOME IMPROVEMENT		all home owners	all living at low density
SOCIAL EFFECTS	SAVINGS OF UNPAID TIME IN 2001		nil	some
SOCIAL EFFECTS	ACCESSIBILITY IMPROVEMENT		nil	some
SOCIAL EFFECTS	LIFE EXPECTANCY INCREASE		nil	slight
SOCIAL EFFECTS	ENVIRONMENT		Some decrease in neighbourhood visual aesthetic values. Otherwise no effect.	Some decrease in local street traffic. Otherwise no effect.

CHAPTER 18

TRAFFIC OPERATIONS

By traffic operational improvements we mean the use of traffic engineering techniques such as regulation of parking and turning, one way streets, channelization, computerized signal control and freeway metering.

Canadian cities are already making reasonable progress in the use of such techniques and it is expected that they will continue to do so. The full potential benefits are not being achieved, however, because of financial, educational and planning constraints. Computerized signal control and freeway metering is the best example of a technique with potential benefits not being fully realized. There are others also, such as:

- more aggressive parking restrictions
- more aggressive use of channelization and of bus stop bays
- pedestrian and vehicular grade separations.

If the current constraints were removed, then it is estimated that by 2001, annual economic net savings of some $29 per capita per year could be achieved. These savings could be distributed to all consumers of the products carried by urban trucking and to all users of buses and autos.

In addition, there could be significant environmental improvement, substantial accessibility improvement and savings of unpaid time of about 27 man hours per capita per year. The environmental improvement would be achieved through reduced congestion and thereby reduced air pollution.

The findings concerning traffic operations are summarized on table 18t1.

TABLE 18t1

SUMMARY OF EFFECTS

OF TRAFFIC OPERATIONAL IMPROVEMENTS

DESCRIPTION OF IMPROVEMENTS			Install computerized traffic control, freeway metering and other traffic operations improvements.
NEUTRAL PATH CONDITION			Current practice continues
APPROXIMATE CONFIDENCE LIMITS			-30% +30%
TIME STREAM	EARLIEST LIKELY YEAR FOR SIGNIFICANT BENEFITS		1975
	AMOUNT OF FIRST YEAR BENEFITS AS % OF 2001		20
EXTRA CAPITAL INVESTMENT REQUIRED			$0.35 Billions
ECONOMIC EFFECTS	TRANSPORT COST SAVING	TOTAL NATIONAL IN 2001	$0.9 Billions
		PER CAPITA INCOME IMPROVEMENT IN 2001	$29/cap/yr.
	DISTRIBUTION OF INCOME IMPROVEMENT		very widely
SOCIAL EFFECTS	SAVINGS OF UNPAID TIME IN 2001		27 man hours /cap/yr.
	ACCESSIBILITY IMPROVEMENT		substantial
	LIFE EXPECTANCY INCREASE		some
	ENVIRONMENT		significant decrease in air pollution

CHAPTER 19

CITY FORM, GRAIN AND ACTIVITY DISTRIBUTION

This chapter summarizes a technical memorandum which was prepared on this topic but which was not issued because of the great uncertainties, not only as to the amount of potential benefits, but also as to their order of magnitude and even whether positive or negative. Even though it has not been possibly, within the scope of this project, to remove these uncertainties, nevertheless, the topic is included here for completeness.

In this chapter we seek to assess the possible impact upon urban transport efficiency of possible variations in land use distribution, which may also be described as variations in urban form, grain and activity distribution.

CHAPTER 19

CITY FORM, GRAIN AND ACTIVITY DISTRIBUTION

19.1 POSSIBLE FORM AND SHAPE CHANGES

In order to maximize transport efficiency, the optimum shape for a city is a circle and the optimum form is for the circle to be completely filled with development, with no gaps, except that a modest amount of clustering is good. This assumes uniform topography and uniform transport facilities.

Cities always tend to assume a circular form, unless they are constrained from doing this, by topography, or limited transport facilities, or land control policies. In the Metro Toronto region, for example, there appears to be a policy of ribbon development, along Lake Ontario, rather than the more circular form which would be more efficient, in terms of transport. The appeal of ribbon, satellite, or finger forms, is to reduce the distance to open country, for both persons and for city waste.

Estimates have been made for City C of the possibility of re-arranging the developed land into a more compact, more circular form. It has been estimated that this would result in moving about 10% of the population from an average distance of about 9 miles from the CBD to an average distance of about 7 miles. This two mile saving, for 10% of the CBD trips, creates about a 1/2% saving in marginal metro transport costs, which, because there will be savings on non-CBD trips also, we have increased to 1%. One per cent of marginal transport costs for 2.3 City C's is $83 million per year in 2001.

In order to bring about these savings of a more circular shape, it is necessary to spend more capital funds on overcoming topography for sewer, water and transport facilities. These increased capital costs are estimated at between 0.3 billion and 0.5 billion for all of Canada, over the next thirty years, which would reduce the savings to about half.

The cost of undeveloped, but serviced, pockets of land, is very high, because the investment has been made, but the services are not utilized. These types of pockets, therefore, are highly inefficient, whereas the open spaces which are left for parks and which are left between clusters are just the reverse: quite efficient, because they are planned to remain as open space for all time and services are not provided for them. Clustering, which is just the reverse form to pockets, brings two transport benefits also. Within a cluster, more trips are brought within practical walking range and secondly, clustering tends to improve transit economy and service.

Possible benefits from pocket reduction and increased clustering have been estimated at about $0.06 billions per year in 2001, which, when added to the net benefits of a more circular shape, give a total of $0.1 billion of net economic benefits from improved form and more circular shape.

The transport benefits are very widely distributed to all consumers and all travellers in the metro region. They might tend to be somewhat more, proportionately, to the middle and lower income groups who travel more in the suburbs.

Concerning social effects, the proposed changes would give some improvement in accessibility, some savings in unpaid time and a slight reduction of accidents, all as a result of reduced travel. On the other hand, the increased distance to "open country" may be considered an environmental detriment, because there is less natural dillution of pollution and because recreational travel to "open country" is somewhat increased. Pockets of serviced, but unused land, are

commonly an"eye sore" and community nuisance. The increased recreational travel to "open country" is small compared with other travel savings and, therefore, on balance, the net social effect of the proposed change in form and shape is decidedly, but modestly, beneficial.

Because of the crudeness of the estimates and the considerable uncertainty attached to them, we have shown very broad confidence limits of -75% and +200%.

19.2 IMPROVEMENTS THROUGH MORE CONCENTRATED CBD

In spite of the fact that there are a couple of U.S. technical studies that appear to deal with this topic, nevertheless, when they are carefully examined, there is surprisingly little of practically useful knowledge which comes from them.

If the CBD were of a single land use, then more concentration would simply be coarser grain and the transport costs would, thereby, be increased, as discussed in the next section. It is only concentrations of mixed uses which has a chance of increasing transport efficiency. This would have the same effect as clustering. One would expect that greater transport efficiency would result in a combination of greater CBD concentrations of both employment and population, provided the central housing is the type to attract the central workers. This is a major proviso, however, and one which introduces considerable uncertainty. Furthermore, although the total amount of transport may decrease, the unit cost of transport is likely to increase with more CBD concentration. We have found it impractical to estimate this cost variance within the scope of this project.

It is our opinion that there are some transport benefits to be realized by greater CBD concentration of a well designed controlled-mixed land-use type, but we believe that substantially more studies are required, in order to assess the possible magnitude of these benefits and how they should be achieved. In particular, more information is required concerning how to design a CBD and its transportation system so as to achieve the optimum social advantages. Unfortunately, there is a great dirth of information of the type that is required to do realistic evaluations on this subject.

19.3 FINER GRAIN OUTSIDE CBD

Finer grain indicates maximum scatteration with each activity being distributed very broadly throughout the region. An extreme example of fine grain is a craftsman manufacturing products behind the store where they are sold, with craftsman, merchant and their families living above the store.

Coarse grain indicates maximum concentration where each major activity is confined to a small number of areas, each reserved exclusively for that activity. A large industrial park containing no commercial or industrial development would be an example of coarse grain.

At the present time, there is a strong trend toward coarse grained development, which, of course, requires mechanical transportation. This can be illustrated in the case of schools, shops, offices and factories.

In the case of schools, it has been common practice to have neighbourhood public grade schools, so located that the younger children may walk to and from school. This practice continues with most public high schools, but, for the more specialized high schools, colleges, and private schools, most children require mechanized transport. Currently, there are some proposals for much larger, combined schools*. Such proposals seek to achieve reduced school cost and increased quality, as a result of economies of scale. The larger the schools, of course, the coarser the grain, and the smaller the school, if the small schools are evenly dispersed throughout the neighbourhoods, the finer the grain. The advantages of the larger schools appear to be increased efficiency in the school operation through more efficient use of specialized equipment, facilities and staff. Those considering the benefits of larger schools usually overlook the disbenefits, due to the increased transport cost of the pupils and staff. There is a possibility, however, that the latest electronic devices for teaching might be very versatile and could be applicable to the neighbourhood school, which would then gain a greater flexibility and broader usefulness. This may be one instance where there could be some practical substitution of communications for transportation. In this case, it would be shortening the pupil's trip by tak-

* See, for example, Progressive Architecture, April 1968 (86).

ing him only to a neighbourhood centre, where he is able to communicate electronically with the widest assortment of teaching aids, rather than moving him a much greater distance to the location of the special facilities and expert resource people.

The old style corner grocery store, with no provision for parking is an example of fine grained shopping development. Most of the customers walk to the corner store. By contrast, the regional shopping centre requires that practically all customers drive and, generally speaking, the larger the shopping centre the lower the percentage of shopping trips which will be made to it by walking. For the last decade or more, the trend has been toward the coarser grained, large, regional shopping centres, for several reasons. In the first place, it satisfies a planning policy for the segregation of activities. This policy derives from the self interest of home owners who protest against a drug store next door (so there is none for miles). Secondly, it improves the efficiency of shop operations, because the larger shops are able to operate more efficiently with respect to specialized labour and services, including deliveries. Thirdly, the large, regional centre is convenient for the shopper, because he is able to make one stop and do all of his shopping. Lastly, because of their size, they receive good design attention and usually are pleasant and enjoyable places to visit. The shopper is generally not conscious of his additional expenditure on transportation in travelling to a large, regional shopping centre.

Offices and manufacturing plants gain efficiency by clustering. For example, a large research centre where a number of industries establish research facilities permits some sharing of specialized equipment such as computers and other speciality laboratory and testing equipment, and permits the establishment of service firms to serve the research community. It also provides for convenient, formal and informal communications between the scientific staff. The cost, in terms of greater travel by the staff, is usually not considered. Communities usually aggressively promote the industrial park or scientific park.

The total effect of the trend toward coarse grained development is that trips by automobile become longer and more frequent. The disadvantage to this type of development is appreciated by the family that finds it must have a second car; and by the housewife who finds that she has become a chauffeur and messenger, spending most of her time running about on errands, in her second car.

It is exceedingly difficult to estimate the magnitude of savings that might be achieved by departing from the neutral path in the direction of finer grain. Certainly there are some strong forces in our society which favour the coarser grained development. It is certainly not a black and white issue, but one with a wide spectrum of possibilities.

Land use planners have, for many years, been seeking the benefits of the ideal "self-contained" neighbourhood of 5,000 to 10,000 people, which, in concept, is a fine grained cell. The concept is fraught with many practical problems. Studies have been made to determine the minimum size of the market for each specific type of retail store and service. Not many can be supported by 5,000 people. Furthermore, the greater the variety among these 5,000 as to income, social class, and household composition, the greater the variety of goods and services required and, consequently the greater the threshold of size of the establishment which is needed to supply them.

Fine grain, of course, requires dispersal of employment, as well as of services and this is very difficult to achieve.

There is, thus, clearly some optimum grain arrangement, which is a combination of fine and coarse. This can be illustrated by suburban shopping centres which were previously mentioned as an example of coarse grain. They are this, of course, to the extent that they serve as an alternative to neighbourhood stores. But to the degree that they serve as an alternative to CBD shopping they are "fine" grain. Certainly, if outside the CBD there were only those services that could be supported by a market of 5,000 people, the total length of all trips in a big city would be much greater than it now is.

The optimal combination of fine and coarse grain could be evaluated using modelling tools presently becoming available. We believe this would show the optimum to be more toward fine grain than the neutral path.

Early in this project an attempt was made by intuitive judgement of a number of experts, meeting in a special session for this purpose, to put a figure on how much reduction in travel might be achieved through new thrusts which would move more in the direction of fine grain for new neighbourhoods outside the CBD. This

session produced a figure of 10% as a possible reduction from the neutral path, in auto and transit travel. This 10% reduction, applied to marginal costs only, would produce a national savings in 2001 of approximately $1.3 billion. In the light of the difficulties of achieving these benefits and the fact that they would not apply to goods movements, and the lack of reliable information on which to base the assessment of their quantity, we have discounted this estimate to $200 millions per year in 2001, which is compatible with the results of computer run #3.

The benefits of fine grain would be distributed very widely throughout the community. Indeed, there might be a possibility of getting a substantial portion of the benefits into the hands of those of low incomes and those otherwise disadvantaged by the auto domination of transport.

The social benefits of the transport effects of fine grain are significant and all positive:- unpaid time saving, accessibility improvement, safety increased and environment improved. The social issues involved in fine grain are much broader than the transport effects. These issues have been presented forcefully by Jane Jacobs They are the subject of considerable debate.

The acceptance or rejection of finer grain will, thus, probably be decided on questions other than transport.

19.4 SUMMARY

There is considerable uncertainty concerning the magnitude of the potential benefits through changes in city form, grain and activity distribution, but certainly this is a topic worthy of much further investigation. It certainly needs to be approached from a much broader perspective than that of transportation alone. Transport should be only one of a number of factors to be evaluated. The following table 19t1, summarizes the results of the evaluations done under this project.

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* See Ref (87)

TABLE 19tl

SUMMARY OF EFFECTS OF CHANGES

IN CITY FORM, GRAIN AND ACTIVITY DISTRIBUTION

DESCRIPTION OF IMPROVEMENTS			More circular shape & fewer pockets	More concentrated CBD	Finer grain outside CBD
NEUTRAL PATH CONDITION			Present off-circular shape + pockets	as present	as present
CONFIDENCE LIMITS			-75% + 200%	uncertain	-50% +100%
TIME STREAM	EARLIEST LIKELY YEAR FOR SIGNIFICANT BENEFITS		1980	uncertain	1980
	AMOUNT OF 1980 BENEFITS AS % OF 2001		5	-	5
EXTRA CAPITAL INVESTMENT REQUIRED			\$0.3 billion to \$0.5 billn.	some	nil
ECONOMIC EFFECTS	TRANSPORT COST SAVING	TOTAL NATIONAL IN 2001	\$0.1 billion	probably some	0.2 billion
		PER CAPITA INCOME IMPROVEMENT IN 2001.	\$3	probably some	\$6
	DISTRIBUTION OF INCOME IMPROVEMENT		very widely	to C.B.D. users	very widely
SOCIAL EFFECTS	SAVINGS OF UNPAID TIME IN 2001		some	probably	significant
	ACCESSIBILITY IMPROVEMENT		some	probably	some
	LIFE EXPECTANCY INCREASE		slight	slight	slight
	ENVIRONMENT		deteriorated because distance increased to "open country"	possibly better depends on design	debatable

CHAPTER 20

TRANSPORTATION CORRIDORS

This chapter is a brief summary of the separate technical memorandum on improvements attainable through transportation corridors. The transportation corridor proposal is that land be set aside now, in broad corridors, for future transport, so that when the need for new facilities arises, they can be constructed in good order, without costly acquisition and destruction of already built up communities.

The opportunity to acquire central city corridors has, for practical purposes, already passed and there is no need to act early on inter-city corridors, thus the benefits identified for transportation corridors are for corridors through the urban fringe.

In order to demonstrate that it is practical to acquire land many years ahead of need, for transportation purposes, the approximate design criterion have been developed for transportation corridors and corridors have been laid out for a theoretical city.

If a program were launched in the near future, of corridor acquisition, then by 2001 the annual per capita economic costs and benefits would be as follows:

Table 20tl

CORRIDOR UNIT COSTS AND BENEFITS

	$/CAPITA/YEAR		
	CITY A	CITY B	CITY C
BENEFITS			
Through avoiding the purchase of already improved property	2.5	4.5	8.0
By avoiding community disruption	1.2	2.0	3.0
By improved travel efficiency	3.1	4.8	10.1
TOTAL	6.8	11.3	21.1
COSTS Extra travel (year 2001)	2.7	4.2	8.7
NET BENEFITS	4.1	7.1	12.4

When these unit savings are applied to the anticipated 2001 population, the net benefit becomes approximately $250 million per year. If the fund which would need to be set up now to make this program possible, of $½ to $1 billion, were treated as a capital investment, then the benefits represent a rate of return of 12.8% to 7.4% on this investment. Various arguments are presented, however, as to why it is overly conservative to treat this land acquisition by government at market prices as a normal capital investment.

In addition to the economic benefits, there are some very substantial social benefits. The avoidance of community disruption is the greatest of these and it will achieve major environmental benefits. In addition, there are savings in unpaid time, accessibility improvement and some safety improvement. The social impact of transport corridors is probably the greatest aggregate of social benefits of any assessed in this project.

Benefits from corridors are very widely distributed to all inhabitants of the region.

The only problem with transportation corridors is that a fund must be set up now, whereas the benefits do not begin to appear for a considerably number of years.

The effects are summarized in the following table 20t2.

TABLE 20t2

SUMMARY OF EFFECTS

OF TRANSPORTATION CORRIDORS

DESCRIPTION OF IMPROVEMENTS			Before land is subdivided reserve wide corridors for transportation facilities.
NEUTRAL PATH CONDITIONS			No special corridor acquisition
APPROXIMATE CONFIDENCE LIMITS			-0% +200%
TIME STREAM	EARLIEST LIKELY YEAR FOR SIGNIFICANT BENEFITS		1980
	AMOUNT OF 1980 BENEFITS AS % OF 2001		25%
INITIAL CAPITAL INVESTMENT			\$½ to \$1 billion. But note that total capital investment over 30 years, including the initial sum is reduced.
ECONOMIC EFFECTS	TRANSPORT COST SAVING	TOTAL NATIONAL IN 2001	\$0.25 billions
		PER CAPITA INCOME IMPROVEMENT IN 2001	\$8/cap./yr.
	DISTRIBUTION OF INCOME IMPROVEMENT		very widely
SOCIAL EFFECTS	SAVINGS ON UNPAID TIME IN 2001		significant
	ACCESSIBILITY IMPROVEMENT		significant
	LIFE EXPECTANCY INCREASE		some
	ENVIRONMENT		major improvement

CHAPTER 21

PRICING

This chapter is a summary of the technical memorandum concerning improvements atainable through pricing.

Many possible variations of road and transit pricing have been explored. In particular, the British studies on road pricing have been gone into thoroughly. It has been concluded that a somewhat different approach is required for Canada. With the rapid expansion of Canadian urban transportation systems, it is reasonable to consider road capacities as expandable, and, thus, to include the cost of this expansion of road capacity as a part of the marginal cost, in a marginal cost pricing analysis.

Taking this approach, a combination of pricing changes has been developed which it is believed would be advantageous and practical for Canada. These include:

- parking charges to reflect the full cost of the parking service, including land rent,
- special motor vehicle license, using possibly a coloured sticker, the display of which is required in order to gain access to key routes in rush hour,
- motor vehicle licences to vary by vehicle type and axle load, so as to reflect the marginal long-run cost of strengthening roads for heavier vehicles,
- toll charges at very expensive crossings,
- transit fares adjusted to be less off-peak and to reflect marginal cost differences between modes.

It is estimated that if all of these measures were put into effect, the total economic benefit would be in the order of $100 million per year by 2001, and that in addition, there would be some modest social benefits as well.

The benefits would be concentrated in the C.B.D. and in routes leading to it where congestion could be somewhat relieved through pricing. There would also be some benefits to transit users, particularly off-peak users, who would get a somewhat better deal.

The social benefits would be modest but broad: some reduction in unpaid travel time, some improvement in accessibility, some accident reduction and some environmental improvement.

There is substantial institutional inertia to be overcome in achieving these benefits and there is some doubt if the magnitude of the benefits would be worth the effort. It is extremely unlikely that such measures will be instituted broadly. It could hardly be in more than three cities and the benefits would be decreased by some other proposals, such as improved transit and traffic operations. Nevertheless, there may well be some of the pricing ideas which will find useful application in some situations in Canada.

The results are summarized on the following table 21t1.

TABLE 21t1

SUMMARY OF EFFECTS

OF CHANGES IN PRICING

DESCRIPTION OF IMPROVEMENTS			Combination of pricing adjustments.
NEUTRAL PATH CONDITION			Roads - arbitrary pricing at about average cost. Transit - pricing at average cost less subsidies
APPROXIMATE CONFIDENCE LIMITS			-20% to +80%
TIME STREAM	EARLIEST LIKELY YEAR FOR SIGNIFICANT BENEFITS		1975
	AMOUNT OF 1975 BENEFITS AS A % OF 2001		30%
EXTRA CAPITAL INVESTMENT REQUIRED BETWEEN 1966 and 2001			nil
ECONOMIC EFFECTS	TRANSPORT COST SAVING	TOTAL NATIONAL IN 2001	$0.1 billions
		PER CAPITA INCOME IMPROVEMENT IN 2001	$3/cap./yr.
	DISTRIBUTION OF INCOME IMPROVEMENT		principally to C.B.D. & transit users
SOCIAL EFFECTS	SAVINGS OF UNPAID TIME IN 2001		slight
	ACCESSIBILITY IMPROVEMENT		slight
	LIFE EXPECTANCY INCREASE		slight
	ENVIRONMENT		slight improvement

CHAPTER 22

TRANSIT OPERATIONS

This chapter is a summary of the technical memorandum entitled "Improvements Attainable Through Transit Operations".

Included under transit operations are all of the changes to a transit system, which may be made to improve its economic or social efficiency, without the use of new technology.

A careful exploration has been made of some 20 or 25 possibilities for improving transit operating efficiency. It has been found that some modest economic improvements can be made, but that the principal benefits are social efficiency improvements. Indeed, it is considered likely that any modest economic efficiency gains that can be achieved will be, in fact, used up in purchasing social improvements.

One of the greatest problems facing transit today is to know how to go about effectively providing the needed social efficiency improvements.

There are a number of well accepted changes that should be pushed further for improving both social and economic efficiencies. These include:

- Express Bus Services
- Exlusive Bus Lanes
- Exclusive Transit Streets
- Bus Stop Bays
- Diversification of Services
- Improvements in Bus Design
- Improved Maintenance Techniques
- Improved Surface Bus Planning
- Convenience Facilities
- Improved Communications
- Dynamic Demand Routing
- Contract Management
- Pricing Policies

In addition to these more conventional approaches, however, it is also proposed that some less conventional ones such as small-vehicle, drive-yourself transit or subsidized car pools, be developed, with the specific objective of improving the social efficiency, and that particularly for the group of Canadians who have special needs in this regard.

Transit can be one of the more effective tools for achieving some specific social efficiency improvement, particularly for the disadvantaged. Careful evaluation is required of each specific proposal, in relation to the social goals, because some of the more common transit "improvements" may not produce the desired results.

The study findings are summarized on table 22t1.

TABLE 22t1

SUMMARY OF EFFECTS

OF TRANSIT OPERATIONAL IMPROVEMENT

DESCRIPTION OF IMPROVEMENTS			Improve transit service by a variety of methods using present technology
NEUTRAL PATH CONDITION			Current practice continues
APPROXIMATE CONFIDENCE LIMITS			Results considered moderately conservative
TIME STREAM	EARLIEST LIKELY YEAR FOR SIGNIFICANT BENEFITS		1976
EXTRA CAPITAL INVESTMENT REQUIRED			Modest
ECONOMIC EFFECTS	TRANSPORT COST SAVING	TOTAL NATIONAL IN 2001	$0.1 billion
		PER CAPITA INCOME IMPROVEMENT IN 2001	$3/cap./yr.
	DISTRIBUTION OF INCOME IMPROVEMENT		principally to transit users
SOCIAL EFFECTS	SAVINGS ON UNPAID TIME IN 2001		3 man hours/cap./yr.
	ACCESSIBILITY IMPROVEMENT		substantial, particularly for the disadvantaged
	LIFE EXPECTANCY INCREASE		some
	ENVIRONMENT		reduced air pollution

CHAPTER 23

NEW TECHNOLOGY

The original terms of reference for this project specifically included new technology and, therefore, in the first phase a certain amount of analysis and evaluation was carried out. This included one computer run to assist in evaluating the benefits from "programmed modules".

The terms of reference for the preparation of technical memoranda and for the revision of the main report specifically excluded new technology, however, and, therefore, the work on new technology is in an incomplete form.

Enough work was done in the first phase, however, to indicate that a great deal of information is available from U.S.A. and European sources, concerning new technology. This information, which has increased substantially in the past 12 months, if it is carefully and critically scrutinized, does contain enough significant cost and performance data, to permit the application of the methodology of this project to an assessment of the potential benefits for Canadian urban transportation.

Because Canadian cities have a greater proportion of their growth cycle ahead of them, than do cities in most other parts of the world, the new technology could be of greater consequence to Canada, than to other countries.

One of the most interesting new technological possibilities is for a fully automatic transit system, which provides a standard of service that is competitive with the automobile. In order to achieve this, economically, it is probably necessary that the vehicles be small and that the system be adaptable to handle both people and goods. We have termed this type of system, of which there are a large number of prototypes and proposals, a "programmed module". Our preliminary analysis indicates that there are substantial possibilities for it in Canada, in the forecast period. Indeed, it appears to hold out the prospect of bringing substantial improvements, both economically and socially.

CHAPTER 24

SUMMARY & CONCLUSIONS

This project has taken a broad-brush bird's-eye view of the dramatic growth and change which the remainder of the 20th century will bring to Canadian cities, and of the social and economic benefits which might be achieved through transport. In this concluding and summarizing chapter we do not consider the study methodology (this was summarized in Chapter 14). Neither do we review the new transport theory which is presented in Chapter 3, or the proposed new subdivision of the subject presented in Chapter 4, or even the significant novel use of both social and economic indicators. Rather we deal exclusively with the results, the findings and their import for further research and policy development. The sectional headings employed are:

24.1 SUMMARY OF FINDINGS

24.2 IMPROVING ECONOMIC EFFICIENCY

24.3 IMPROVING SOCIAL EFFICIENCY

24.4 INTERACTION OF LAND-USE AND TRANSPORT PLANNING

- 24.4.1 Downtown Re-development
- 24.4.2 New Development
- 24.4.3 City Size

24.5 MOVING PEOPLE, SERVICE VEHICLES AND COMMODITIES

24.6 GOVERNMENT AND FINANCE

24.7 RESEARCH PROGRAMMES

- 24.7.1 Develop Social Indicators
- 24.7.2 Evaluate Transit's Social Impact
- 24.7.3 Develop Experimental Neighbourhoods
- 24.7.4 Commodity Flow Research
- 24.7.5 Develop Transportation Corridor Design Techniques
- 24.7.6 Develop Land Economics
- 24.7.7 Improve Transport Models
- 24.7.8 City Size, Shape, Grain, etc.
- 24.7.9 New Technology

24.1 SUMMARY OF FINDINGS

Table 24 t1 gives a comprehensive but highly condensed summary of the project findings.

We consider that this table assesses all practical improvement to Canada's urban transport system and its effect, both socially and economically. Each assessment is not to the same level of accuracy, but the body of the table gives some hints as to which information is the less reliable.

- Trucking + New Technology
- Arterials & Freeways + New Technology

There are also some possibilities of combinations producing benefits greater than the sum. The best example is

- Corridors + Arterials & Freeways

As the urban transport model that was used lies at the heart of the analysis in this report, the reader is advised to carefully review Appendix D on Transport Models, especially the sections dealing with their deficiencies (D.1.5) and future development (D.4). The ability of the TRANS model to accurately predict future urban movements, particularly auto and transit use, has a critical bearing on all the conclusions discussed in this section. A clear understanding of how the model works and its shortcomings is vital to understanding the results summarized below.

24.2 IMPROVING ECONOMIC EFFICIENCY

By 2001, Canada's ten major cities will contain about 22 millions of people (55% of the total), compared with about 8 millions in 1968 (40% of the total). The average per capita income in 2001 is expected to be about $4,000 in 1966 dollars, compared with $2,000 in 1966. This year 2001 income, in real terms may be increased further, by some 7%, by improving the quality of the transportation system.

SUMMARY & CONCLUSIONS

	TRUCKING CONSOLIDATION	TRUCKING IMPROVE FACILITIES	ARTERIALS & FREEWAYS SPACING	ARTERIALS & FREEWAYS PATTERN	CORRIDORS	ACCESS ROADS LOWER STANDARDS	ACCESS ROADS IMPROVED PATTERNS	TRAFFIC OPERATIONS	CITY FORM & SHAPE	CITY C.B.D. CONCENTRATION	CITY GRAIN NON-C.B.D.	PRICING	NEW TECHNOLOGY	TRANSIT OPERATIONS
NEUTRAL PATH CONDITION	Truck terminal quality & truck load factors remain as 1966	Percentage of truck time for P & D remains as 1966	Facilities proposed for 1980 to 1986 in current published plans will, in fact, be built by 2001	Continue with present basically, rectangular grid form with some discontinuities	No special acquisition of transportation corridors	Current standards continued	Current practice continued	Current practice continued	Present off-circular shape + pockets	C.B.D. similar to present	Grain as at present	Roads - arbitrary pricing at about average cost. Transit - pricing at average cost less subsidies.	No new Technology	Current practice continues
IMPROVEMENT STUDIED	Consolidate - -shipments -terminals and -trucking	Better shipping-and-receiving facilities and improved paper-work	Improve spacing i.e. build more arterials and freeways	Improve pattern - -more nearly square -less discontinuities	Before land is subdivided, reserve wide corridors for transportation facilities	Use only "Adequate" standards	Better subdivision patterns	Install computerized traffic control, free-way metering & other traffic operations improvements	More circular shape & fewer pockets	More concentrated C.B.D.	Finer grain outside C.B.D.	Combination of adjustments	"Programmed module" and other new technology systems.	Improve transit service & efficiency by various methods using present technology.
EXTRA CAPITAL INVESTMENT REQUIRED BETWEEN 1966 AND 2001	nil	small	$1.8 Billions	small	$0.5 to $1.0 Billions initial capital but not "EXTRA"*	Negative as quantified below as annual amount	nil	$0.35 Billions	$0.3 Billions to $0.5 Billions	some	nil	nil	large	modest
ECONOMIC EFFECTS – TRANSPORT COST SAVING – TOTAL NATIONAL IN 2001	$0.8 Billions	$0.4 Billions	$1.8 Billions	$0.4 Billions	$0.25 Billions	$0.5 Billions	$0.25 Billions	$0.9 Billions	$0.1 Billions	probably some	$0.2 Billions	$0.1 Billions	$1 Billion to several Billion	$0.1 Billion*
ECONOMIC EFFECTS – TRANSPORT COST SAVING – PER CAPITA INCOME IMPROVEMENT IN 2001	$26/cap/yr.	$13/cap/yr.	$58/cap/yr.	$14/cap/yr.	$8/cap/yr.	$15/cap/yr.	$8/cap/yr.	$29/cap/yr.	$3/cap/yr.	probably some	$6/cap/yr.	$3/cap/yr.	$32 to $100/cap/yr.	$3/cap/yr.
ECONOMIC EFFECTS – DISTRIBUTION OF INCOME IMPROVEMENT	all consumers	all consumers	very widely	very widely	very widely	all home owners	all living at low density	very widely	very widely	to C.B.D. users	very widely	principally to C.B.D. & transit users	Very widely with special benefits to those now disadvantaged	principally to transit users in large cities
SOCIAL EFFECTS – SAVINGS OF UNPAID TIME IN 2001	nil	nil	78 man hours /cap/yr.	24 man hours /cap/yr.	significant	nil	some	27 man hours /cap/yr.	some	probably	significant	slight	substantial	3 man hours/cap/yr.
SOCIAL EFFECTS – ACCESSIBILITY IMPROVEMENT	nil	nil	substantial	some improvement	significant	nil	some	substantial	some	probably	some	slight	substantial	substantial particularly for the disadvantaged
SOCIAL EFFECTS – LIFE EXPECTANCY INCREASE	slight	nil	some	slight	some	nil	slight	some	slight	slight	slight	slight	substantial	some
SOCIAL EFFECTS – ENVIRONMENT	Although consolidation will modestly improve environment, a much more substantial environmental improvement is possible through trucking by improving vehicle designs so as to decrease noise and air pollution.		Sight, sound and smell are not necessarily affected but the mobility of the poor is likely to be decreased.	Slight improvement	Major improvement	Some decrease in neighbourhood usual aesthetic values. Otherwise no effect.	Some decrease in local street traffic. Otherwise no effect.	Significant decrease in air pollution	Slight decrease because distance increased to "open country".	Possibly improved. Depends on design.	Debatable	Slight improvement	Very great improvement.	Reduced air pollution.
NOTES	Reliable trucking data is very scarce and thus bold assumptions were necessary for this assessment.		Attempts to build new arterials & freeways after a community is developed frequently brings violent objections with validity. From a long-term view these may be most effectively overcome by corridors.		*With corridors the total capital investment over 30 yrs. is reduced but more of it is placed at the first of the period.	Transportation benefits through access roads can only be achieved by improving the transport planning in subdivision design.		This visualizes a Canadian programme similar to the U.S. T.O.P.I.C.S. but with emphasis on computerized control and less benefits because Canadian operations start from a better base.	There are substantial uncertainties about benefits from change in city form grain and activity distribution and furthermore transport will properly be only one of a number of considerations in making such changes.			Could involve some double counting. Unlikely to be achieved at all fully because of institutional inertia.	New Technology was only explored in a preliminary way in the first phase of the project. These results are thus subject to greater uncertainty than others.	*Potential benefit not likely realized but rather used to increase social benefits.

To appreciate the flexibility of the potential use of these benefits, one must appreciate that essentially they are not increases in the G.N.P. They are just the reverse. They are savings and one way of utilizing them, at least in part, is as savings which, in effect, reduce the G.N.P. There are a number of other ways in which the benefits may be employed:

- cost of production may be decreased and the products, thereby, made more competitive internationally, which, in turn, will result in greater output.
- benefits may be distributed in the normal way to the populus, who will use them to acquire more goods and services, including more transport.
- benefits may be distributed in a special way to the populus, so as to solve some special social problem, such as unemployment or immobility of the disadvantaged.
- a combination of the above.

The measures which have been found to be most effective in attaining better economic efficiency are the following:

- improve the spacing and pattern of arterials and freeways. Transportation corridors and improved planning are the most effective methods of achieving these improvements.
- new technology.
- consolidation of trucking and improvements of shipping-and-receiving facilities.
- improvement in traffic operations, including particularly, computerized controls.

24.3 IMPROVING SOCIAL EFFICIENCY

Not only may the economic efficiency improvements be used for social purposes, but also there are a number of the proposed transport changes that make substantial direct contributions to social goals.

The reservation of transportation corridors can achieve a major environmental improvement by avoiding community disruption due to transport facility construction and by removing noise and air pollution from residential streets.

New technology also holds the possibility of major environmental improvement by the removal of noise and air pollution.

Improvements in the spacing and pattern of freeways and arterials and traffic operational improvements are the most effective means of saving unpaid travel time and improving accessibility. The freeway features which have caused public objection may be overcome by a combination of transportation corridors and improved environmental design of facilities.

Urban transit bears special mention in this connection, because transit, including both operations and new technology, is the only means which can be made applicable directly to one of the most significant social problems associated with transport, namely the relief of the transport disadvantage experienced by those people who, through poverty or driving disability, are placed at a disadvantage by our present urban transport systems.

24.4 INTERACTION OF LAND-USE AND TRANSPORT PLANNING

There is clearly a vital interaction in the effects of land and transport development; and a similar vital interaction is certainly desirable in land use and transport planning.

24.4.1 Downtown Re-development

The downtowns of most North American cities have been approximately stable in employment, population and person trips for the past 20 years. Population and employment growth has been rapid only in the suburbs.

"Strangled" is rather too severe a term to describe the effect of congestion upon downtown but there is little doubt that traffic congestion and high land prices contributed to the retardation of downtown redevelopment.

The downtown congestion problem is the result of many factors including:

- narrow streets inadequate for use by modern goods vehicles.

- through traffic growth, declining vehicle occupancy and diversions from transit to auto.
- pedestrian-vehicle conflicts produced by traffic growth.
- illogically priced parking,resulting in cruising in search of parking and/or inadequate supply of parking.
- comparatively small sized land holdings.
- obsolete truck docking and shipping-and-receiving facilities.

The tools for solving this downtown transport problem are becoming available but their effective application requires redevelopment. Such redevelopment need not require long term subsidy but it will require imaginative and dynamic action with regard to both transport and the other essential elements of such redevelopment.

Transportation will play a key role in such redevelopment and, in particular, the following transport developments require careful planning attention:

- improved shipping-and-receiving facilities.
- consolidation of trucking.
- new technology for downtown circulation systems.
- pedestrian grade separations.
- rationalization of parking prices.
- rationalization of peak hour road use pricing.
- street arrangements to facilitate transit and traffic operations.

24.4.2 New Development

Some of the greatest long run economic and social benefits which we have identified are through improved new development planning, so as to optimize the spacing and pattern of arterials and freeways.

One of the most effective methods of achieving long term improvement of spacing is to reserve wide transportation corridors for use by all types of transport facilities, including transit, pipelines and power lines, as well as arterials and freeways.

In the few instances where transport planners have provided unusually wide street or highway rights-of-way (for example Portage Ave. in Winnipeg and 401 in Toronto) they have been a great blessing later when widening is required. The concept of transportation corridors is to reserve systematically, well ahead of development, corridors for roads and other transport facilities.

Corridor reservation avoids the destruction of buildings and avoids the painful dislocation of people and communities. These wasteful practices are one of the principal deterrents to the supply at present of an adequate freeway system.

To make transportation corridors a reality it is necessary:

- to improve planning techniques.
- to provide a legal mechanism for corridor reservation.

and at one time only

- to supply a revolving fund for purchase of property as required.

24.4.3 City Size

Although the project terms of reference clearly exclude evaluation of optimum city size, nevertheless, the findings regarding transport cost variation with city size are so spectacular that some comment is required. The following is neutral path data for 2001:

CITY SIZE (millions of inhabitants)	ANNUAL PER CAPITA TRANSPORT COST IN DOLLARS		
	PEOPLE	GOODS	TOTAL
0.29	293	167	460
1.22	332	235	567
5.56	460	538	998

NOTE: - excludes other urban travel and access roads which are included in table 13t5.

This spectacular increase of transport cost with city size is only part of the story because:

- in the larger cities there is substitution of urban transport for inter-city transport.
- in the larger cities people choose to travel farther, even though they could use shorter trips. Presumably they receive benefits from the longer trips which are at least equal to the extra cost.
- part of the increased transport cost is the price paid for greater accessibility.
- some of the cost in the large cities is moving goods which are consumed in smaller cities.

The tools which have been developed on this project could be used for further reserach on this topic, but it should be pursued as multi-disciplinary research, considering not only transport, but also other factors which vary with city size.

24.5 MOVING PEOPLE, SERVICE VEHICLES AND COMMODITIES

Moving people is an important part of urban transport. It consumes about half the annual urban transport dollar. Over the past 25 years transit has declined from 210 rides per capita per year to 60 rides per capita and person travel by auto has increased accordingly. Transit now accommodates less than 10% of the urban people movements. Transit currently faces serious problems of declining service and patronage and increasing costs. We predict that measures currently forseen and expected will bring help to transit to the extent of holding current patronage levels. Some further gains can be made through further operations improvements, but a substantial return to transit will only be achieved through new technology which does hold this possibility. In planning future assistance to transit for moving people, however, we consider that the point most needing emphasis is that the social ends being sought through transit must be clearly identified. If a social need is clearly identified, such as for example, access to employment for a certain low income group, or access to amenities by the aged and infirm, or access to schools, then these can be rationally evaluated, solutions development and appropriate finance arranged.

Moving service vehicles has not been given sufficient attention as part of urban transport. Ambulances, fire trucks, power and telephone repair vehicles and

the like, unlike people in autos, have no alternative but to use the roads. The peculiar needs of these service vehicles should be given more attention in urban transport planning.

Moving goods or commodities absorbs almost half the urban transport dollar. Most of the economic benefits which we have identified, through arterials and freeways and corridors, for example, are gained through improved goods movement efficiency. In addition, there are a number of specific improvements for commodity flows which merit careful attention. These include:

- consolidation of trucking, shipments and terminals.

- improved shipping-and-receiving facilities and paper work.

24.6 GOVERNMENT AND FINANCE

Questions of government and finance are not strictly within the scope of this project. Nevertheless, some items, which have an important bearing upon government and finance, have come to light during the course of the study. These are, therefore, only mentioned here to point out items requiring further attention.

At present there tends to be a wide divergence between the recommendations resulting from engineering and economic studies and the action which is actually taken. Part of the reason is that government organizations have difficulty in being sufficiently flexible to adapt to the expanding geographic area and long time span which need to be considered if long term urban transport benefits are to be achieved.

Canada has taken some world leadership in developing regional governmental structures and it appears that moves even further in this direction are required for efficient and effective urban transport planning.

It has become popular to talk about the finance of the municipal government's share of urban transport expenditures, as being a major problem * beyond the municipality's financial capability. There appears to be a need to re-evaluate the finance of urban transport.

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* See for example the Canadian Federation of Mayors and Municipalities First Canadian Urban Transportation Conference, Feb. 1969 "Regional Study Papers" p116 and elsewhere in "Proceedings" and "Regional Study Papers" (15).

One thing that stands out clearly is that the road user is willing to pay the full cost of very good road facilities. All he asks is for some governmental machinery to allow him to buy what he wants. Possibly the sharing of costs by several government levels is a part of the problem and a change in the taxation structure is what is needed. Transit finance is in a much different situation. There, the user is not willing to pay the full cost and what is needed is a careful evaluation of the social goals and benefits, so that more rational facility designs and financial participations may be developed.

24.7 RESEARCH PROGRAMMES

The results of this project may be used to rationalize a comprehensive programme of urban transport research. We have demonstrated this by developing a preliminary research programme priority matrix, using anticipated benefits and probabilities on each particular programme to calculate a relative priority.

Some of the particular research items which have been identified during the project are as follows. This does not proport to be a comprehensive list:

24.7.1 Develop Social Indicators

The important social factors may be approached technically, either through welfare economics or through social indicators. The social indicator approach is considered the most promising at present, because it should be able, most quickly, to re-establish the essential dialogue between technician and politician. The function of social indicators may be to fill the time gap until analytical sociology and economic analysis are developed far enough to deal with these problems. Therefore, this project has used an embryonic social indicator approach. But, priority needs to be given to research into quantitative social indicators relating human goals and the quality of the living environment.

The full force of our present inadequate ability to make social evaluations is felt when one realizes that at present there is no way of determining whether community A is better or worse than community B, from

the viewpoint of total human habitation. In the final analysis, land and transport planning practices are based upon the intuition and personal judgement of a few people. It will not be possible to develop a more scientific planning process until a body of empirical data can be produced which quantifies people's reaction to various living and transport possibilities.

24.7.2 Evaluate Transit's Social Impact

Possibly the most striking need for social research is in the impact of urban transit. The benefits to be derived from improved transit are largely social benefits to specific sectors of the community - in particular, the poor, children and inform, who do not have access to auto transport. Some very costly new transit schemes are completely ineffective in helping these community groups who need it most. thus, research is needed to evaluate the social impact of various transit proposals upon the several significant community sectors, particularly the disadvantaged.

24.7.3 Develop Experimental Neighbourhoods

The factors influencing the character of residential neighbourhoods include:

- building codes and other regulations.
- land subdivision practices
- existing and expected transport.

The only way to improve cities is through new or redeveloped residential neighbourhoods that provide a better living quality. This improved living quality is possible through an improved combination of a number of elements, including transport. But, we must be able to positively identify a "better" neighbourhood when we achieve it. This we cannot do at present. The most direct research approach to this problem might be to design and build a series of experimental neighbourhoods under carefully controlled conditions, so that valid measurement may be achieved of the cost (capital maintenance and operation) and of the social value and of the public reaction. Some present neighbourhoods would be used as control areas for comparison. The market response and user attitudes could then be used to measure quality.

The following transport proposals lend themselves to testing in this way:

- Access road standards changed to decrease cost, but combined with imaginative drainage and landscaping schemes.

- New Neighbourhood Transit Systems such as dial-a-bus or dynamically programmed jitneys or rented mini-autos.

- Simulated Inter-Neighbourhood Transit System Some outstanding features of an experimental neighbourhood might be dependent upon the characteristics of a new or improved inter-neighbourhood transit system. It would not be practical to build a complete city wide network of inter-neighbourhood transit links for a test of one neighbourhood, but it would be possible with careful selection, design, and somewhat higher cost, to simulate the characteristics of such a system as perceived by the residents of the experimental neighbourhood.

24.7.4 Commodity Flow Research

Urban goods movement is a seriously under-researched topic which merits development, particularly of the following subject areas:

- improved shipping-and-receiving facilities.
- improved trucks.
- consolidation of trucking.
- consolidation of shipments.
- consolidation of terminals.
- trucking costs.
- commodity flow demand.

24.7.5 Develop Transportation Corridor Design Techniques

In order to develop transportation corridor design techniques, it is suggested that a pilot programme be initiated to design in some detail, transportation corridors, for two specimen Canadian cities.

The research on arterial and freeway spacing which has been initiated under this project needs to be pursued further and this might be done either as part of a corridor research project or independently.

24.7.6 Develop Land Economics

The discipline of land economics is not able to contribute as it should, to urban transportation planning, particularly in the issue of land value as it relates to land price, accessibility, and governmental action, including transport corridor reservation. Priority needs to be given to research on these relationships based upon empirical Canadian data.

24.7.7 Improve Transport Models

The most promising current development in urban transport planning models is in the application of systems analysis techniques which segregate transport costs by all meaningful breakdowns (people and goods segregated, for example) and give evaluatory information in terms of both economic and social indicators. This method was employed on this project, but it would benefit from much further development.

Pilot urban planning projects might be initiated with the special objective of the development and testing of improved systems transport planning models.

Such techniques would need to consider social evaluation by sectors of society. At the national level there are special concerns affecting transport planning, namely:

- regional disparities
- national vehicle safety standards
- national manufacturing standards
- the supply of data
- research coordination

These point to national interest in the structuring of urban systems transport analyses methodology.

24.7.8 City Size, Shape, Grain, etc.

These topics have been considered to some degree in this study. Indeed, in section 24.4.3 some suggestions are made concerning research on city size. The project has also found that a circular shape is the

most efficient for transport and that there appear to be transport benefits from finer grain. These appear to be promising subjects for further research but it would be a mistake to try to optimize city character only from a transport viewpoint. Therefore, this city character research needs to be undertaken from a broader viewpoint with transport as one important element.

24.7.9 New Technology

There are significant opportunities for benefits in both social and economic efficiency, through new urban transport technology and, therefore, this is a potentially fruitful field of research, which could be approached as a continuation of that done in this project.

APPENDIX A

WELFARE CHANGES DUE TO TRANSPORT IMPROVEMENTS

APPENDIX A

WELFARE CHANGES DUE TO TRANSPORT IMPROVEMENTS

The purpose of this appendix is to present a theoretical expression of the relationship between transport improvements and changes in welfare. The methodology of the analysis is based on indifference curves analysis developed by Sir John Hicks.* The method of two commodities analysis is used and the possibility of its extension to n commodities is accepted without further proof.

The analysis is focussed on the position of an individual making his locational choice. It is assumed that the individual has a certain budget allocation for the costs of maintaining a satisfactory habitat. This budget is spent in such a way as to maximize the individual's satisfaction from his residential choice. Of all items which enter into his "total satisfaction from residence" we single out two - living space and accessibility - as the most relevant ones for our analysis. We assume, therefore, that an individual would have a special utility-from-accessibility function (f(a)) which is inversely related to the time necessary to travel from his residence to places of interest; and utility-from-living space function (f(l)) which is inversely related to density of population in an area. Both the accessibility and living space functions are increasing functions subject to saturation constraints.

Residential property values are assumed to reflect the desire of individuals to maximize their accessibility and living space utilities. The cost of residential properties can thus be considered as consisting, implicitly, of two cost components, one associated with accessibility, and the other associated with living space.

The costs of accessibility can be described by a function c(a). The index measuring the costs of accessibility is the

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* J. R. Hicks, Value and Capital (88)

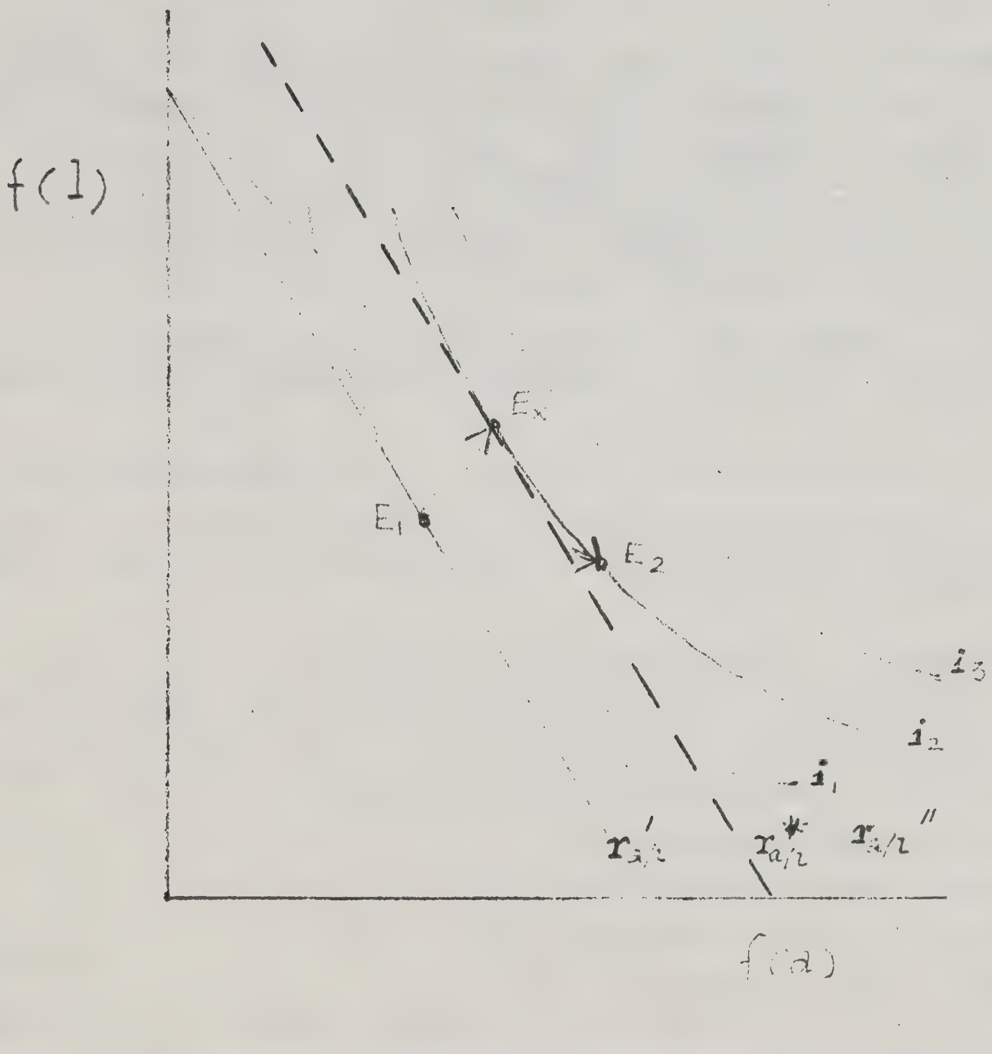
part of property value related to the time-distance point of interest.

The cost of living space is described by the function c(c) which relates living space to costs net of location function. Given c(a) and c(l) it is possible to calculate cost ratios of availability of living space and accessibility, $f_{a/i}$. Given f(l) and f(a) it is possible to construct the individual's preference map - (Fig. Af1). On this map each line i_1, i_2.....represents the combinations between benefits of living space and accessibility which the individual considers to be equivalent. i_2 is considered to be preferred to i_1. Given the budget of the individual, i.e. the part of his income which he decides to spend on the costs of city living, then the $r_{a/l}$ line may be constructed and the individual's optimum point, can be derived. This point is the point of tangency of the $r_{a/l}$ line and the highest i curve which he can achieve given no income limitations (i.e. $r_{a/l}$ lines represent both budget limitations and price ratios). In the case represented in our diagram this point is E_1. Now, let us assume that due to transport improvement, the trip which used to take him 60 minutes, i.e., that the benefits of accessibility have improved for him, and also that at the same cost he can move user to a higher point on f(a) axis. This is equivalent to an improvement of his welfare if, and only if, the actual adjustment of his position took place. But even if no adjustment did take place he would still be better off (see Fig. Af2). By not moving to a different position which would give him $0l_2$ living space and $0a_2$ accessibility but preserving his previous position he would finish with $0l_1$, (as before) living space and $0a_3$ (less than $0a_2$) accessibility. This would put him on i_2 curve instead of a higher i_3 line. This is equivalent to an income increase from $r_{a/l}{}^{1}$ to $r_{a/l}{}^{11}$ rather than to $r_{a/l}$. Why? The costs of moving etc. may exceed his gains from a new position. In fact, we may expect a mixture of situations - some persons moving, some staying put - thus the "real income" gains would likely be somewhere between the movement to the highest possible curve and i_2 curve on our Fig. Af2.

This analysis can be generated to a greater number of factors.

The consumers' welfare function can be represented in income; without this improvement he would have to spend more to move within 30 minutes to his centre of interest while enjoying the same living space. However, two factors are

FIGURE Af1



operative here:

(i) income effect, or the effective increase in "real income"

(ii) substitution effect. Since accessibility is now "cheaper" in real terms, more of it is likely to be consumed if the substitution effect is "positive".

Diagramatically, the income effect is represented by $\overline{E_1E_x}$ vector, and the substitution effect by $\overline{E_xE_2}$ vector. The total effect of adding $\overline{E_1E_x}$ and $\overline{E_xE_2}$ is a move toward higher consumption of accessibility and living space. A move from E_1 to E_x represents the improvement in the consumer's welfare, equivalent to income improvement which is represented by a parallel move of $r_{a/i}$ line to $r_{a/}$.

A word of caution must be interjected here: the city dweller would achieve the maximum improvement of his general terms as

$f_1(x_1) + f_2(x_2) + f_3(x_3)$ .....to be maximized subject to the income constraints, and costs functions. Changes in transport conditions in all cases result in income effects and substitution effects.

This approach, although somewhat different, is consistent with that adopted by Lithwick and Paquet*, and also adopted as a starting point for their urban land use investigation the following model of consumer's behavious: The consumer is supposed to maximum <u>objective function</u> $U_i = f_i(L_i, T_i, C_i)$ subject to income <u>constraint</u> $Y_i = P_L L_i + P_T T_i + P_c C_i$ where i represents the ith individual, L_i is the quantity of land used by i, T_i is the transportation input, C_i is a composite commodity - all commodities consumed by i excluding land and transportation, P the price of relevant input, f_i is the general representation of the utility function, U_i is the i^{th} individual's income.

The difference between ours and the Lithwick-Paquette approach is that we assume individual's utility or welfare being related to his accessibility (i.e., reciprocal of time spend on transportation), rather than to transport input; transport input is considered here only as a cost of achieving maximum accessibility.

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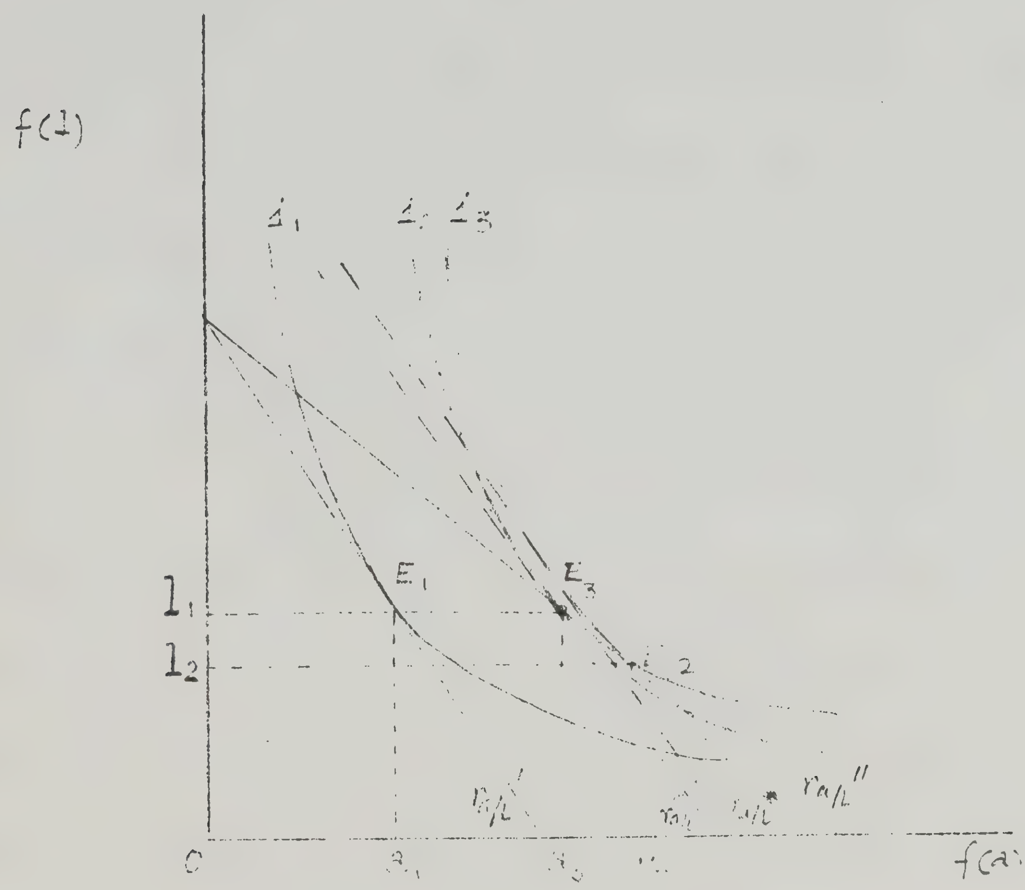
* See Lithwick and Paquette, ref. (53), p.119.

FIGURE Af2



APPENDIX B

LAND USE MODELS

APPENDIX B

LAND USE MODELS

B.1 INTRODUCTION

Land use models describe future land use distribution. The acceptability and relevance of land use models depends on the state of the art, which is currently in a period of rapid evolution. This appendix makes a broad evaluation of the current situation and future expectations.

Broadly speaking, land use models play two roles in transportation planning and evaluation. A third role may develop in the future.

The first role (General Projection Models) is quite conventional and continues to be of major importance. This is the bread and butter function of predicting land use patterns and occupancy, to be used as inputs for the transportation planning process.

The second role (policy Sensitive Projection Models) is closely related to the first, but differs from it in that the models used are more sensitive to policy inputs and in particular to transportation policies. Such projection models can therefore hopefully be used to project the impacts of transportation plans on land development. This lays the basis for further refinement of the transportation planning process and at the same time for evaluating transportation plans in terms of their impacts on land uses.

The third of the forseeable applications for land use evaluation models will be to combine some aspects of projection with selected aspects of evaluation, and thus to provide powerful means of measuring the impacts of total plans on the resident population.

B.2 SALIENT PROBLEMS OF URBAN MODELS

The essential character of land use models is that they are locational and therefore partake of many aspects of location theory.

This theory is a branch of economics or economic geography, and consequently makes use of economic concepts having to do with the costs of inputs to production and consumption processes and the costs of transportation which are necessary to bring together the factors of production and consumption. In this context it follows that transportation inputs and interaction costs are an important part of all land use modelling.

B.2.1 Interaction between Land Use and Transport Systems

A serious problem exists in using land use models for predictions of the impact of transportation system on development pattern due to mutual interactions of the two: the land use development pattern determines the demand for transportation, while at the same time the demand for transportation, given the state of the system, determines congestion, quality of service, etc. which in turn affect the land use pattern. In static analysis this problem may be handled by specifying either the transportation system or the land use pattern and investigate the effects of changes of either. Alternatively, the transportation system may be specified in terms of level of service which it will provide ratios than in terms of fixed facilities. This approach, however, would make an overall optimization analysis impossible. The most satisfactory solution would be in terms of a dynamic model with the inter-actions of land use and transportation and feed-backs and time-lags specified in the structure of the model. Such models, however, have not been fully developed, even in a theoretical form, let alone in a form capable of quantative testing, although some useful empirical work in this direction must be noted. (See para. B.3.6).

If this is done, the size of the facilities required to meet a given level of service is an output rather than an input, and this makes a financial or economic evaluation very difficult. The circularity problem can theoretically be overcome by dynamic interaction between transport and land use models (i.e. iteration).

B.2.2. Location Theory

There are a number of major distinctions between conventional locational theory and locational theory as

it is or could be embodied in models of urban metropolitan areas. In the first place, most locational theory applies to the location of industry rather than of households. This means that urban locational theory must develop or utilize theories of consumer behaviour which do not form part of conventional locational theory. In the second place, many of the hypothetical decisions of conventional locational theory are all-or-none optimal decisions by all actors, such as the decision to buy a particular product from a single lower cost source. This type of theory does not accord well with the observed behaviour of tripmakers or shippers in the urban area. In the general economic sense, the breakdown of this theory may be attributed to product differentiation, for which not wholly adequate theories of producer and consumer behaviour exist. In the third place, the urban situation is characterized by relatively intense competition for land as site. In much inter-regional industrial location, the cost of land does not ordinarily enter either into theory or into practical decisions. Within the city, however, the contrary is true. Since the determination of the prices of land is essentially simultaneous with the determination of location, a rather large problem of market simulation and optimization arises. This problem has been solved only in part, if at all. Fourth and finally, urban location phenomena are strongly influenced by economies and diseconomies of agglomeration -- that is, by "externalities". This influence is found in all location theory, but perhaps more acutely so in urban location.

Appendix A gives a suggested approach to location theory considering the impact of transport. Much further empirical work is required before such a theory can be useful in land use modelling and it is possible that the living space-accessibility interrelationship will be overshadowed by non-transport factors which make it practically impossible to obtain the necessary empirical data.

B.2.3 Activity Distribution or Area Composition

As Lowry points out in his paper, "Seven Models of Urban Development", (56) there seem to be in principle two basic styles by which simple projections of land use patterns can be made. A natural third style arises out of the possibility of combining the two processes.

We are looking generally at the problem of distributing a number of activities such as residential, commercial and manufacturing land occupancy over a number of sub-areas, say transportation zones or census tracts. In each case, the units of activity and of area may be more or less disaggregated. We can and do look at these distributions from either of two points of view. One point of view is to consider the distribution of each activity over zones. In this case, we notice the peaking of commercial densities at the core, the peaking of residential densities around a small crater but near the core, outlying regional shopping centers, and the specialized radial and circumferential distributions of manufacturing. A second view is to consider the composition of the activities which are located within each particular zone. Thus, we may find that a zone contains five percent commercial, thirty percent residential, zero industrial, and sixty-five percent vacant land. Combinations such as these tend to distinguish land in various locations within the city; the tract which we have just described is obviously a peripheral suburban zone, but possibly with an unusually high proportion of commercial activity.

It is also especially instructive to consider these two views of the distribution of activities to areas over time. The first view focuses on the relocation of activities. Over time we can obtain information about the decentralization of employment and residences, the growth of suburban centers in a general way, and the like. From the second point of view, we focus mainly on the succession of activities in neighborhoods. These changes are equally important since they are related to the installation, obsolescence, and ultimate replacement or renewal of both public and private capital facilities. They are also related to the types of demands which are placed upon the transportation system and other public services.

Also quite obviously these various analyses are related in very complex ways both within themselves and to each other. The decentralization of commercial activity is at least in part a result of the decentralization of residential location. The transition of one zone into manufacturing land uses may be intimately related to the previous transition of an adjacent zone. Also important, the relocation of

populations obviously influences the composition of zones, and is in turn influenced by this changing composition. Thus for example, the growth of middle-class residential location in the suburbs may be internally determined as a response to increasing income and mobility, or it may be externally determined by the changing industrial and demographic composition of zones lying closer in. In the ideal and completely developed model, all of these interactions would be realistically taken into account.

It has turned out in practice that model builders have tended to emphasize one or another of these two main aspects while taking account of the other aspect only to a minor extent. A more complete discussion of this problem will be found in the reference work by Lowry (56). Most present models find their motive power in the redistribution of activities and the composition of areas is an output resulting from that redistribution. Composition as a causative factor enters into such models mainly through a definition of maximum densities and segregation of land uses. This approach to the interaction between area composition and locational preferences is perhaps unfortunate, since it is well known that densities and intensities of development respond in fairly sensitive ways to the pressures of development, while locational preferences and distributional patterns for subsectors of the population seem in their turn to depend in a sensitive way on the presently available choices of densities.

B.3 CURRENT LAND USE MODELS

There is a long and respectable history of the descriptive modelling of urban development patterns. We omit any detailed consideration of the theories or principles involved in these models, and simply refer briefly to the existence of operational methods for making land use projections.

B.3.1 Residential

The first of such models, still quite viable, are the methods which were used by the Chicago Area Transportation Study to destribute future residential development. Somewhat similar, but distinct methods have been developed by Lowry in his "Model of Metropolis" (57) and by Lathrop and Hambury for the New York State

Division of Highways' Niagara Frontier Study (see Journal of the American Institute of Planners, May, 1965 (58)). All of these models require as input some definition of holding capacity of areas. None of them distinguish between different classes of the population, such as may need to be distributed for the realistic estimation of transportation demands. In the event that the distribution of population to dwelling units by income and family size is required, special methods of matching the population to the projected residential facilities must be provided. This is usually done by relating household characteristics to districts, but there is no very well defined model for discharging this task. In addition to these largely descriptive models of residential location, some effort has been made to develop more analytic and economically based models of residential choice. The most ambitious of these models have been based on the preference concepts developed by Alonso, Muth and others and embodied in particular in the Herbert-Stevens model. On the supply side, the Arthur D. Little Company explored the provision of housing in the San Francisco market area. Most models of these types are very promising in the long run, but seldom exist in immediately usable form.

B.3.2 Retail Trade

In the field of retail trade location, there are two or three broadly competitive types of descriptive models. The simplest is probably that embodied in the Lowry "Model of Metropolis" parallel with residential location and depending strongly on transportation modelling concepts. In this case, retail trade trips from home are distributed in accordance with a modified gravity model formula which varies for different lines of business. It may be important to note that an attractor for such trips is land area rather than trade opportunities, and thus the iterative character of the next few models to be discussed is side-stepped. There is some iteration in that Lowry sets minimum sizes per square mile for certain types of retail trade clusters and at least one iteration must be used to see whether these threshold sizes are or are not achieved. Simple concepts of gravity model retail trade distribution have been discussed by Huff and have been developed into models by Lakshmanan and Hansen, Harris, and Fidler.

All of these models imply in some sense a balance between supply and demand and must be iterated as a method of solution. Possible iterations over time have a different meaning and are discussed below.

A very different approach based on the utilization of central place theory has yielded excellent descriptions of retail trade distribution. These methods have been developed especially by Brian Berry and his school, and are well discussed in the monograph, "Commercial Structure and Commercial Blight" (59). As far as can presently be determined, this elegant system of analysis is basically unsuitable for making projections, since it requires a predetermination of trade areas. Such trade areas, although overlapping, fall more or less naturally out of the operation of the models described in the preceding paragraph.

B.3.3 Office and Institutional

The location of many offices and their associated services may conceivably be regarded as branches of retail trade and may at least be projected through the use of the Harris model above. The reliability of such projections is probably questionable, and it must be recognized that no very good models presently exist for determining the future relative importance of central city office centers, suburban office centers, and dispersed office location. In this connection it may be suggested that many important locators, including government and institutional employers, must in any event be predicted on the basis of planning considerations rather than market-type models.

Similar considerations apply to a number of other public services and especially to the provision of public open space, which is a considerable consumer of land and generator of trips, even though it has low employment. It seems possible and likely that more market-oriented methods of locating public facilities such as open space will be developed in the next few years and that a combination of public policy and private demand may be predicted as influencing this location.

B.3.4 Industrial Location

Industrial location has in recent years proved very difficult to model. The classical organization of

industry is undergoing a number of technological changes, and the relative importance of various inputs such as land and skilled labor appears to be changing. Predictions as to the future impacts of manufacturing industry in the nation as a whole and in any particular region are becoming somewhat more uncertain, but this impact probably strongly influences the likely location of industrial activity within the metropolis. Analytically we must contend with the slow adaptation of industrial location to change, and with the short history (ten to twenty years) of the massive recent changes which seem to be taking place. While it seems likely that policies in transportation and changes in other land uses will influence industrial location, it is not at all clear that enough data are available to be able to sort out the influence of these factors in such a way as to be able to construct a model. It is quite clear that the equilibrium tendencies of manufacturing industrial location if they exist are even more obscure and difficult to model than the trends. Some indications are available that these difficulties may gradually be overcome; see,for example, the work of Putman in Pittsburgh. Meanwhile, the existence of strong zoning policies in relation to manufacturing location suggests that some such location may be projectable without the use of a model. This is especially true since the control over the location of manufacturing industry appears to be less subject to political erosion than parallel controls over commercial and office location and residential densities.

B.3.5 General Descriptive Models

Owing to the comprehensive informational needs of transportation studies, there have been a number of efforts to develop comprehensive descriptive models which deal with all types of location. A few of these are discussed briefly at this point and further references will be made in the next section.

One such descriptive model deserves particular mention for certain distinctive characteristics; this is the EMPIRIC model developed by the Traffic Research Corporation (now Peat, Marwick and Livingston) for the Boston Region. This model deals explicitly with the change in the location of all significant employing and residential groups, and it regards this location and relocation as an interactive process which is controlled partly by the pressure for expansion, partly

by competition, partly by the interaction between location groups expressed through accessibility measures, and partly through considerations of density, amenity, and public policy. This model has very interesting properties; their meaning is not always altogether clear. The calibration of the model requires detailed information for two points in time, which has proved difficult to secure in practice.

The Lowry "Model of a Metropolis" lends itself to expansion in a comprehensive form if provisions can be made for locating so-called basic industry. This model has been expanded in this way in a number of places, one of the more ambitious efforts being the BASS family of models, the title of which refers to the Bay Area Simulation Study. These models have been utilized in a somewhat different form by the Bay Area Transportation Study Commission under the title of "PLUM". A still different development is mentioned below.

B.3.6 Equilibrium and Growth Models

There is inherent in various modelling efforts a duality in the attitudes toward urban growth and form. Many of the models imply some sort of equilibrium. Such models include the original CATS Land Use Model, the Lowry model, the various retail trade models discussed above, and many others. Such equilibrium models can in principle be used at any future point in time without regard to the intervening events. From this point of view, therefore, they are very useful for exploring some of the long range implications of urban policy and taking a "snapshot" of the implications of possible future development patterns. They are, on the other hand, not very useful for exploring the implications of short range stepwise development. For this latter purpose, it is considered stylish to have available in some form a model or collection of them which may be considered in some sense a "growth model". Such growth models generally make it possible to project the future development of a metropolitan area (under alternative policy assumptions) in increments of five or ten years. This procedure has a number of possible advantages, both analytical and technical. On the analytic side, more information can be gained about the sequencing of public investments and other implications of a planned course of development. On the technical side, the steps in the recursive model provide a more or less automatic way of dealing with the interactions between the different activities and thus to some extent may

substitute for iterative solutions to equilibrium problems.

The family of growth models includes many extensions of the equilibrium models previously discussed. Thus, the Time Oriented Metropolitan Model (TOMM) developed by CONSAD Research Corporation for the Pittsburgh CRP is an extension of the Lowry model into a growth model with some allowances for residential preferences. The Penn Jersey Transportation Study originally proposed to use the Herbert-Stevens model of residential location in a growth context. The actual Penn Jersey Activity Allocation Model used the Harris Retail Trade Model in a growth model context. There is reason to believe that the EMPIRIC Model and similar growth models like the Penn Residential Location Model have equilibrium concepts embedded in them, although what is measured is a set of equilibrating tendencies, rather than equilibrium states. Finally, there are some models, such as the Lathrop-Hamburg Model, which do not appear to have any equilibrium implications at all, but which can respond in a growth pattern to repeated external impacts, in this case, new population.

B.3.7 Market Models

It appears likely that the next generation of land use models, some of which are currently under development, will contain a number of market models which will provide for still more penetrating analyses of locational patterns and their consequences. Market models may be distinguished according to whether they emphasize most strongly the supply side or the demand side.

The Arthur D. Little model for the San Francisco CRP was primarily a supply-side model. Dealing as it did with the standing stock of housing in a large central city, it attempted to model changes in the housing stock which would result from entrepreneurial behavior when confronted by various levels of demand, and under alternative public policy assumptions. Many previous market models have dealt, in the field of housing, mainly with the supply of new dwelling units and not with changes affecting the supply of existing dwelling units, and this model represents an advance in this regard. It is, however, not fully operational and does not have any features relating to the transportation conditions of the metropolis. It does not, in fact, deal with the whole metropolitan area.

The above-mentioned Herbert-Stevens model is essentially a demand model for residential housing and at the most takes for granted the supply of the standing stock and the entrepreneurial behaviour of the builders of new housing. It takes into account the effects of the transportation system by way of accessibility and within limits it deals with the interaction between supply and demand through a linear programming formulation. This model has proved difficult to implement because of problems in the necessary preference analysis, but it promises to provide a truly economic analysis of housing and land prices.

The substantial advantage of market models which properly take account of the influence of policy is that they can predict not only location, but also prices, and, they therefore provide an excellent framework for cost-benefit analysis. In this framework, a market model would permit the analyst to take into account the impact of improved transportation on lower housing costs or greater consumption of space or both. This type of improvement in models will represent a whole new level of efficiency analysis.

The discussion so far has been restricted to residential location because market models for non-residential location are much less completely developed. The retail trade models discussed above assume a type of market equilibrium, but the competition for land and the cost of land does not enter into the analysis because of the overriding ability-to-pay of most retail trade activities. This is a shortcoming which is evidently much more severe in relation to many other types of locational behavior. There is a broad spectrum of manufacturing, services, and office locations which are undoubtedly influenced by the cost of space, but inadequate work has been done on the various economic aspects of this which need to be understood to make model building possible.

It appears likely that, insofar as land prices, costs, and benefits have to be calculated, this will be feasible in the near future only for residential location. Non-residential location will have to be handled mainly by descriptive models.

B.4 APPLICATION OF LAND USE MODELLING IN URBAN PLANNING

The question naturally arises as to how land use model-

ling may be used technically in urban planning, what type of resources are required, and how much flexibility is available to agencies in dealing with land use modelling problems. There are a few easily defined and fairly clear outstanding features of this problem which deserve mention.

Land use modelling, except of the most elementary trend projection type, must proceed in a computer-based environment in which a large proportion of the technical staff has computer know-how and relatively extensive technical facilities are available. Most present land use planning staffs cannot be easily adapted to a computer-based planning activity and must be regarded as essentially an auxiliary task force, even though it may have a number of very important roles.

Most land use models not only have a transportation bias, but also have been developed wholly or in part in connection with transportation planning. As a result of both these influences, almost all such models have embedded in them concepts of accessibility, trip attenuation, the friction of space, etc., etc. They also have implicit concepts such as density which are frequently used in transportation planning but which are derived essentially from land use planning practice. Many, but not all, such models actually make use of standard transportation models. At any rate, the transportation planning concepts and methods are on the whole congenial to practice in this field.

The data requirements of land use projection models are somewhat exigent. In selected cases, data collected for standard transportation surveys may prove adequate. These selected cases involve a number of assumptions.

- First, the methods used must require data for only one point in time, and consequently must have to do essentially with equilibrium. This assumption probably proves least satisfactory in the case of manufacturing employment and land use.

- Second, economic models of locational behaviour are ruled out because the ordinary transportation survey obtains inadequate information on the costs and condition of space.

- Third, the transportation survey is not regarded as wholly self-contained; it is on the contrary assumed that some substantial inputs as to land use, densities, and employment location are available as a result of auxiliary surveys.

Data requirements for trend models, growth models, and economic models may be more extensive than those just outlined. Trend projections at least are likely to be needed in relation to manufacturing employment, and this requires substantial additional information and analysis for checking purposes. Trend data might be desirable with reference to other lines of activity. For growth models such as EMPIRIC, very extensive and detailed information is required for all land uses for at least two points in time. Insofar as it is desired to make projections in fairly considerable detail, models of this type may become very difficult to manipulate. The essential problem lies in finding information on economic activity by small-area location, at an earlier date which is conformable with population data. Economic models of consumer and corporate behavior are also very demanding of data, but are more likely to require these data on a cross-sectional basis and can frequently be satisfied with sample information.

Given a computational capability, transportation models, and adequate transportation and land use data, it would appear that a basis has been laid for land use models. Probably two other requirements are of major importance, and both of these are, by virtue of the present state of the art, difficult to meet.

The average transportation planning agency should have an off-the-shelf capability for engaging in land use projections. In any case, one should not expect the average study or even most central agencies to have the innovative capability of creating such systems from scratch. This creates a dilemma, since most of the models which we have discussed above are not readily available in transferrable form, and some general capability for adapting them at least must exist. This is a major shortcoming in the present state of the art, and there is no good indication as to when it will be cleared up.

The second major problem arises from the nature of the sketch planning process itself, and from the types of

personnel which will be involved in it. This difficulty also implies that ultimately the tests which are being made are tests not only of the transportation plans, but also the associated land use plans. Most of the methods discussed require as inputs not only alternative transportation systems, but also some alternative views of holding capacities. In addition, it may also be necessary in selected cases to project the location of institutions, public facilities, open space, and the like. It is well known that all of these types of independent projections are arduous and troublesome. It is also known that the lack of coordination between land use plans and transportation plans may result in a misjudgement as to the costs and benefits of both of them. Finally, there are particularly difficult personnel problems in that the people who ordinarily prepare land use plans, as suggested above, are not very well related to the computer-based transportation planning processes. There is thus in this area a cluster of problems of concept, technique, and personnel management which have not been solved and which are not immediately about to be solved.

B.5 APPLICATION OF LAND USE MODELLING IN TRANSPORT EFFICIENCY EVALUATIONS

If the impact of changes in urban transportation is to be evaluated in terms of changes in land use such as, for example, changes in residential density, then dynamic policy sensitive economics models are required. No very satisfactory such models have been developed and those which have been developed are very expensive to apply. It would be necessary for the ideal land use model to receive as input a description of the transportation and demographic conditions in a base year and from this to calculate for a future point in time, the area composition of land uses in each transportation zone including residential population, the housing condition, the employment and the land price. Theoretically, such a model might be used in dynamic interaction with the transport model to proceed stepwise through time perhaps on two or three year intervals, to forecast the future impact of variations in transport policy. The present state of the art is not such as to make this procedure possible. Indeed, the basic required theory for such modelling has not been developed and there is a serious question if some of

the major determinants, such as zoning decisions and the locating and use of public lands, open spaces, etc. can in fact, be modelled in a useful way.

Furthermore, even if the ultimate urban model were available, as explained in sections 10.4 and 10.5 it would obliterate most of the changes in efficiency created by transportation change and therefore, would not be useful in measuring efficiency improvements.

Therefore, for purposes of this project, the 2001 land use conditions have been forecast on the basis of trends, using the basic project assumption of unchanged overall densities and using a considerable measure of judgement. For further work, it would be desirable to test the sensitivity of the conclusions of the project, to various assumptions of possibly different land use development.

B.6 POSSIBLE CANADIAN LAND USE MODEL DEVELOPMENT

There has been very little land use modelling done in Canada, except by use of the projection trend technique.* U.S. experience in land use modelling is not directly applicable to Canadian conditions, because of differences in policy and in zoning procedures and possibly because of some difference in living habits. Furthermore, very little is known about the accuracy and reliability of the land use models developed in the United States for U.S. conditions. Neither do we know of any evaluation which has been done of the magnitude of the benefits to be gained from land use modelling. It is conceivable that improved land use models developed for Canadian conditions and applied in Canada would be of great benefit in the land use planning process, as well as in the transportation planning process and could lead to economies and improved efficiencies in our urban areas. This would conceivably be brought about through improved planning processes and through more rapid and better evaluation of various policy options. It is also possible that land use models, including economic evaluation features, could be used to curb land speculation and to provide guidance in the locat-

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* However, studies by Lithwich and Paquette should be noted. (53)

ing of government land banks and the determination of the amount of land required in these banks at any time. Substantial amounts of money would be required, in order to adapt U.S. models to Canadian conditions and make them available to user agencies throughout Canada.

If such a program were carried out with a modest amount of innovative effort, it might require a budget in the order of half a million dollars, say $100,000 per year, over a five-year period. This should be regarded as a base cost, to which would need to be added any costs of developing substantially new modelling or of training and assisting in making such programs operational with the user agencies.

It is recommended that a pilot study should be undertaken, to assess in greater depth the costs and benefits and practical problems of such a land use model research and development program for Canadian conditions.

B.7 SUMMARY

Land use models are a minimum necessity for transportation efficiency evaluation because by some form of projection they establish future levels of demand for transportation. In the foreseeable future, economic evaluative type models may be developed which will make it possible to evaluate both transportation and land use plans more deeply. At present, there is a wide range of variation in the types of land use models which have been developed in the United States. Only the very simplest and most descriptive of such models are operational in a form which can be immediately adapted for conditons in other countries, such as Canada. In general, these simpler models also have simpler data requirements, but most of them need fairly detailed land use and locational information. Others also require data for two points in time. In general, the simpler the model and the less demanding its data requirements, the greater the presumption that its accuracy is not altogether adequate.

The use of land models in the studies leading to this report has been minimal for reasons of cost, operationality, data requirements, and accuracy. It is believed, however, that over the longer run there may be substantial

benefits which will accrue from adapting land models to Canadian conditions. A minimal effort based on adapting existing models and excluding developmental work on new models is discussed and a rough estimate of cost is provided.

APPENDIX C

WELFARE ECONOMICS

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WELFARE ECONOMICS

The problems which welfare economics attempts to solve are:

(1) Analysis of social preferences in order to array the options according to a consistent pattern of desirabilities, e.g. option A being better than B; or, in other words, the society is better off adopting option A than B.

(2) Analysis of indirect or "external effects".

(3) Analysis of political and ethical content of economic statements.

SOCIAL WELFARE FUNCTION

The welfare function represents a consistent ranking of different states of "welfare" or social preferences. Since modern western societies are built very much around the principle of individualism, it is not surprising that modern welfare economics considers individual preferences as the starting point for the construction of a social welfare function.

The basic postulates accepted by most of the western authors dealing with social welfare function are:

(i) Each individual has his own set of preferences.

(ii) Each individual's welfare is optimized if he distributes the resources available to him in such a way as to reflect his set of preferences. In other words, each individual is best off if he can exercise his free choice in using the resources available to him (it should be noted that one of the resources available to him is his time, which he also allocates between leisure, work, etc.).

(iii) The social welfare function is optimized if individual welfare functions are maximized,

subject to corrections necessary through the inter-relationship between individual actions (e.g. an individual's satisfaction from house ownership may be enhanced or diminished through the changes made to the properties of his neighbours) and by communal action which may be necessary if the desirable results cannot be achieved through market mechanism (e.g. street lighting).*

The application of social welfare function analysis is the evaluation of a change - is a proposed change or government action justified? will it leave the society better off or worse off?

COMPENSATION PRINCIPLE

Although some changes cannot be measured directly, methods of indirect measurement can be applied. These methods are essentially based on the principle that an individual, or group of individuals is capable of stating whether a particular change leaves them better off, or, in other words, whether their subjectively evaluated "real income" (which may include non-pecuniary factors) increased or decreased.

Let us assume that a set of benefits (B_c in our notation) is not stated in monetary terms, and that only one member of that set changed.

This would be the case if no member of the society became worse off by this change, but at least one group became better off. Under such conditions the change is clearly for the better.

However, in most cases improvement in the position of one group leads to a deterioration of the position of the other. Even in a simple case of installation of an improved traffic control system, we would have a group of gainers - the users of streets over which the traffic flow improved - and losers, i.e. the taxpayers who have to pay for the improvement. In such a case, we estimate the gains to the users of the system and compare these with the costs of its introduction. In this simple case, the costs of introduction of a system may be accepted as an adequate measure

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* For a rigorous review of welfare criteria and postulates of welfare economics see I.M.D. Little, <u>A Critique of Welfare Economics</u> (89).

of reduction in real income to the taxpayers. However, in more complex cases, the measurements of gains and losses are by no means simple, and it is important to consider the basic principle of such a valuation. Such basic principle can be stated, in general terms, as the compensation principle, which states "if the gainers from a given change can compensate losers from this change and remain still better off, and the losers cannot compensate the gainers, then the change is beneficial"*. The operational application of this criterion is rather difficult in general cases, or where major income shifts are involved. In specific cases, however, it can be usefully applied. Eg. a construction of a limited access expressway may affect adversely living conditions of the owners of the abutting property, and possibly prices of such properties, on the other hand the users of such an expressway would gain in travelling time and costs, this presumably will increase the property values in the feeder area of the expressway; if such an increase is greater than the decrease in property values in the immediate vicinity of the road, plus the costs of the new facilities, the "gainers" (the users of the facility) could "overcompensate the losers (government bearing the costs of the new facility and the adversely affected property owners).

EXTERNAL EFFECTS

It is fully realized that in addition to actions (production and consumption of goods and services) for which an individual or firm is paid (or pays), some individual actions, which are outside the working of a price mechanism affect the welfare of the individuals and production efficiency of the firms**. In the context of urban development such external effects are particularly important; examples of such external effects are:

(a) Property values are affected by the actions of

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* This is a simple re-statement of Kaldor-Hicks-Scitorszky criteria; for the authoritative discussion of this problem see I.M.D. Little, A Critique of Welfare Economics (89).

** In technical language these are called external economics (or benefits) and external dis-economics (or negative benefits). For full treatment of the problem see W.J. Baumol, Welfare Economics and the Theory of the State (91).

owners of neighbouring properties;

(b) Time spent on going to work, and thus allocation of time between leisure and work, is affected by travel of other people, whose travel may create congestion, or, alternatively a large volume of passengers may make it possible to organize a high speed economical transport system;

(c) Vicinity of related production activities may decrease the costs of production *;

(d) Creation of water and air pollution are classic examples of external dis-economics. Noise creating activities - or "noise pollution" - are of the same nature.

COMMUNITY WANTS

There is also a set of important activities which are produced as the result of community decisions, either because their cost could not (without heavy or prohibitive costs) be recovered through consumer charges (e.g. street lighting, use of streets) or which are considered essential for the well-being of the community (e.g. city parks, schools, sewage system**). Since it is impossible to use market mechanism for the provision of such services, the political decision making (in democratic societies), voting must be introduced.

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* This is called "agglomerative effect of location" and explains the attraction of larger centres for some industries. See A. Weber, Theory of Location (90).

** Activities such as police, fire fighting, sewage disposal, etc. require universal coverage to be really effective, therefore, excluding from benefits those who do not wish to pay for them would make everyone else worse off.

APPENDIX D

MODELS FOR TRANSPORT FORECASTING AND PLANNING

APPENDIX D

MODELS FOR TRANSPORT FORECASTING AND PLANNING

D.1 PRESENT STATE OF THE ART IN MODELLING

D.1.1 What are Models

The models referred to here are mathematical models which describe the relationships between various elements of a system. These can be so simple that they can be done in a human head or they can be so complex that the high speeds and great capacities of the largest electronic computers are exceeded. The models employed for urban transport forecasting and planning generally require large electronic computers.

D.1.2 Ultimate Urban Model

To get transport models in perspective it is useful to review briefly the ultimate model which might be constructed to simulate an urban area. An urban area or a city is a very complex organism composed of several elements which may be described as: the Social City, the Demographic City, the Economic City, the Physical City and the Political City, all of which are bound together by a Transport System and a Communications System. An ultimate "urban model" would relate all of these elements together so that the effects of a change in one element, "city" or system, on all other elements could be determined. This ideal model would, of necessity, have to be "dynamic", in the sense that it would operate sequentially over time, as most changes that are made in one element have a delayed effect on other elements which will, in turn, affect the original element.

Ideal urban models of this type do not yet exist. The reasons for this are several: the problem is very complex; the relationships between the various elements of the system are not known; many apparently unrelated disciplines are quite often involved; and

the amount of data processing is so large that it is still probably beyond the capacity of computer technology, although the situation is changing rapidly.

However, although the ultimate urban model has not been, and may never be constructed, several parts of the system have received much attention from model builders. The two major thrusts have been "urban transport models", which attempt to describe the transport system and relate it to the other elements of the urban complex, and the "land use" models, which attempt to relate the Physical City, the Demographic City, the Economic City and the Transport System. The transport models, are generally static models, whereas the "land use" models are generally dynamic. Land use models are discussed in Appendix B.

D.1.3 Why an Urban Transport Model is Necessary

Because of the complex inter-relationships between the various elements of a transport system and of the complex relationships between the transport system and the city, it is very difficult to understand the system without the use of a systems or model approach. A transport model gives a better appreciation, and enables measurements to be made, of the internal operation of the transport system and of the effects of the system on the city. The better appreciation and measurements can then be used to make a choice between various courses of action, such as changes in taxation, in pricing policy, in subsidy programmes, in construction or abandonment of various transport facilities, or changes in city characteristics.

D.1.4 Present Urban Transport Model Technology

Since the mid-1950s modelling has been used extensively in the study of urban transport. The emphasis has been on modelling the internal operation of the transport system itself. These models usually require that data describing the Physical City, the Demographic City and occasionally the Social and Economic Cities be provided exogenously. The outputs from the model are usually traffic flows which are used for facility design and, more recently, systems performance measures such as total travel time and vehicle miles which enable alternate transport systems and alternate land use patterns to be compared.

These models divide the city into zones and describe the interconnecting transport links. The physical and demographic characteristics of each zone and the characteristics of the transportation service provided are then assembled and the relationship between these characteristics and travel "demand" is estimated. The distribution of trips over the transport network is then performed using one of several mathematical formulations, such as the gravity model.

D.1.5 Deficiencies in Present Urban Transport Models

Two particular deficiencies of many urban transport models have been overcome by the model chosen for this study. These are the almost complete lack of attention given to urban freight movement and to a summary treatment of economic costs and benefits. An additional and unsolved problem however, is the difficulty experienced in accurately predicting modal split.

The modal split or market share for each kind of passenger transport depends jointly on (a) consumer demand which is related to such things as travel time, comfort and prestige and is reflected in the amount of each mode used at various prices, and (b) the quantity of transport supplied at a given price, which depends on social and financial costs. To properly predict the future traffic levels of each mode requires a simultaneous analysis of both demand and supply, but because many of the relevant variables cannot yet be properly measured, a simpler, less complete approach is used. The historic pattern of usage (the past equilibrium between supply and demand) is related to an easily measured variable like travel time and the trend is extrapolated forward. While this works reasonably well in shorter term situations, problems arise if consumer preferences change or if the past policy with respect to the supply of roads or transit is altered. These models, for example, often seriously underpredict the usage of new kinds of public transport service such as GO Transit.

For the present, one must proceed on this simpler basis, bearing in mind the limitations of the method.

D.1.6 Regional Transport Models

Modelling regional or intercity transportation is in many ways similar to modelling urban transportation, and the development of both types has followed similar paths. There is one notable exception to this, however, the "Harvard Model", which was developed for use in analyzing intercity transport in developing countries. It is a dynamic model in that it operates on a year-by-year basis, and in addition to simulating the transport network, it attempts also to simulate the economy of the country and to relate the economy to the transport system and the transport system to the economy. Unfortunately, this model has not been successfully tested in practice because of the lack of adequate input data and knowledge of the relationships involved. The transport sector of this model has, however, successfully been used as a static model.

D.2 MODEL USED IN THIS STUDY

D.2.1 Choice of Transport Model for this Study

In choosing a model for use in this study the following were the main criteria used:

(i) Because of the number of runs required and budget constraints, the model must run at low cost.

(ii) It must enable the following transport elements to be evaluated from both an economic and social point of view:

(a) freight as well as person movements

(b) street system characteristics

(c) public transit system characteristics

(d) trucking system characteristics

(iii) It must be able to evaluate the effects of alternate land use plans on the transport system.

(iv) It must be readily available and proven in operation.

Among the many models investigated were the following:-

- B.P.R. package
- Opportunity Models (Chicago and Philadelphia)
- Demand Models
- HUD Modal Split
- K.P.M. Traffic Prediction Model
- ICES TRANSET I and II
- Variations of above (e.g. Smock-Detroit)
- Montecarlo
- TRANS Model

None of the above models was entirely satisfactory and time and budget eliminated the possibility of developing a new package. However, with a few modifications, the TRANS model provided the best compromise solution, as it was readily available and provided most of the information required at a reasonable cost. It is capable of handling person and goods movements by several modes of transport and several different vehicle types, and has a strong economic orientation.

D.2.2 General Description

The TRANS model was originally developed at Harvard University and was adapted by N.D. Lea & Associates Ltd. for use in the Dahomey Land Transport Study, a project carried out under the auspicies of the World Bank for the U.N.D.P. and the Government of Dahomey. It is in the form of a package of computer programmes which can be run on an IBM 7094 or 360/65 or a Univac 1108 computer.

The information required to run the model for a particular area consists basically of a description of the transportation network, a description of the vehicles operating on the network, a description of the commodities to be moved on the network, and a series of equations relating the performance of the vehicles to the characteristics of the network and the amount and type of traffic using the network. The network is described in terms of links and nodes; the links represent transportation routes - road, rail, etc., as well as intermodal transfer facilities - and the nodes represent points where two or more routes join and points where traffic is generated or attracted.

The links are described by their characteristics - mode, length, rate of rise and fall, etc. The programme is presently limited to 150 nodes and 300 links. The vehicles are split into five classes which are described by various characteristics such

as weight, capacity, power, etc., as they relate to each mode considered. The commodities are described by their transportation preference characteristics, i.e., the relative importance of travel cost, travel time, probability of loss, etc., and by the nodes where they are produced and the nodes where they are consumed. Persons are considered in the model as one or more separate commodities. The model presently can handle 40 separate commodities.

D.2.3 Inputs

Six main types are required:

(1) A complete listing of the quantities and characteristics of all commodities which require transportation; this includes, for each commodity, the tonnage and price at each point of supply in each season, the annual tonnage at each point of consumption and the transportation preferences of each commodity.

(2) A description of the physical characteristics of each link in the network.

(3) A description of the rate structure or the rate policy in effect on the links comprising each mode or submode.

(4) Equations for each mode to relate operating cost and performance to link characteristics.

(5) The number and the characteristics of the vehicles operating on each mode in the system.

(6) Present origin and destination data and link flow information to enable the model to be calibrated.

D.2.4 What the Model Does

From the commodity supply and demand data for each node the model determines the distribution pattern of each commodity in turn, using either an inverse impedance (gravity) model or a linear programming formulation - which is based on the minimization of costs as perceived by the shipper. For the first run, costs as perceived by the shipper are calculated using approximate input values for link performance characteristics (costs, travel time, etc.). The distribution process also selects the best combination of mode and route through the network and assigns the commodity flows to

the appropriate links. The resulting commodity flows are accumulated on each link of the network according to vehicle class to show the link utilization. Each link is then analyzed separately, depending on its mode, to determine the vehicle and link cost-performance characteristics. Determination of these cost-performance characteristics includes the calculation of revised tariff on the link using the appropriate pricing policy.

The model can be automatically re-run, or iterated, as many times as desired using the revised link cost-performance characteristics from the previous run as a basis for the new distribution and assignment.

D.2.5 Output

The model gives five types of output:

(1) Commodity flow and cost data for each commodity in each season. The model gives the volume flowing between each origin and destination the actual cost incurred in transportation and the cost as perceived by the shipper.

(2) Link flow data. For each season the model gives commodity and vehicle flows on each link in the system.

(3) Vehicle cost-performance measures. These measures are useful to the transport operator at the micro level in selecting new equipment, etc., and to the project planner in evaluating the effects of proposed changes; they also help in the design of new links. For the highway mode these would be as follows for each class of vehicle:

- crew time and cost
- fuel consumption and cost
- oil consumption and cost
- tire wear and cost
- maintenance (parts and labour) and cost
- depreciation rate and cost
- cost per vehicle mile
- cost per ton mile

(4) Link cost-performance measures. These are items which will affect the shipper's choice of mode and routing and might typically be:

- waiting time
- travel time
- variation of travel time
- probability of loss
- cost to the transporter
- cost to the shipper

(5) Systems performance measures. These are summary statistics for each mode or submode, vehicle type and season and are used by the transporter and the Government in setting rates, computing taxes, etc. They provide a measure of the relative importance of the various modes, the relative intensity of vehicle use and the relative importance of terminal operations. The measures produced are:

- waiting time
- travel time
- terminal time
- transfer time
- vehicle miles
- ton miles
- total costs
- total revenues

The units of both input and output items may be specified as metric, British or U.S., while any suitable currency units may be used.

D.3 APPLICATION OF MODEL IN THIS STUDY

In order to use TRANS for this study, certain modifications had to be made and certain special techniques had to be used to overcome the limitations on network size imposed by this model.

D.3.1 Time Periods

The TRANS model was originally programmed to take annual zonal supply and demand volumes for each commodity and split these into seasons of specified duration and produce distributions and assignments on a daily basis for each season. In this study the daily supply and demand volumes for each commodity were split into two "seasons" representing peak and off-peak periods; distributions and assignments on an hourly basis were produced for each period.

D.3.2 Supply and Demand Node Limitation

To overcome the limitation on the number of nodes available, only one direction of a round trip was simulated. For example, for peak period analysis, only a.m. peak trips were considered. It was assumed that the p.m. peak trips are equal in volume and opposite in direction. A similar argument was applied to the simulation of off-peak travel. For work person

trips it was possible to define up to 20 supply nodes, corresponding to residential zones, and up to 40 demand nodes, corresponding to employment zones. Supply and demand of non-work trips and of goods were treated in a similar manner. A particular supply node may or may not also be a demand node, and vice versa.

D.3.3 Network Size

With the supply and demand zones limited as above, the maximum of 300 one-way links was found to be sufficient for cities up to the 1,000,000 population size, with each link representing either one or a bundle of several adjacent and parallel facilities. A rectangular grid of 80 nodes (10 nodes by 8 nodes) requires a total of 284 one-way links.

D.3.4 Use of TRANS for Large Cities

For City C, splitting the residential areas into 20 zones gives average population per zone of 100,000; at a residential density of 5,000 per square mile, the average zone area would be 20 square miles, say 4 miles by 5 miles. The average length of an intrazonal trip (which does not cross the zone boundary) would be about 3 miles, assuming a uniform grid system. A trip length frequency curve for a typical city of this size indicates that 55% of the trips are shorter than this. As the city doubles in size, the average residential zone becomes 40 sq. miles, implying an intrazonal travel distance of about 4½ miles. The frequency curve shows approximately 70% of trips to be shorter than this. Since the model is unable to distribute these intrazonal trips on the basis of intrazonal travel time, then some procedural modification was clearly required for the analysis of City C.

To overcome this, City C was modelled twice - once for the entire city - and once for the central or downtown section only. In the entire city model, the central section was treated as one "super-zone". The analysis of the entire city provided estimates of the travel between the outlying areas and the central area which were then used as input data for the analysis of the central section.

Although this method necessitates a separate network and supply-demand table for each model, it did not present any insurmountable problems, and it did provide zones of smaller size with significantly reduced intrazonal travel. The main problem was a logistics one of handling, identifying and storing the different sets of input data and of coordinating the output reports.

D.3.5 Intrazonal Travel

For cities of under one million, no adjustment was made for intrazonal travel, as it was assumed that the effect of such travel would be negligible. However, for the larger cities, it was decided that intrazonal travel should be considered. The method of treating this travel consisted first of estimating the percentage of the total travel which is intrazonal travel for each zone, based upon the zone size, and then of reducing by one-half the amount of the intrazonal travel so estimated. The reason for this one-half reduction is that since the model calculated the travel as interzonal, it is judged that the estimated time and cost of the extra interzonal travel might be double that of the same amount of intrazonal travel. Inclusion of this estimated intrazonal travel gives more complete system costs and characteristics.

D.3.6 Commodity Supply and Demand

The following are the commodity categories and the corresponding vehicle categories which were employed:

	COMMODITY CATEGORY	VEHICLE CATEGORY
	1. Person work trips by auto	Auto
	2. Person work trips by transit	Transit
	3. Person non-work trips by auto	Auto
	4. Person non-work trips by transit	Transit
	5. Local goods, general	General
	6. Local goods, bulk	Bulk
	7. Long-distance goods, bulk	Bulk
TOTAL	7 Commodities	4 Vehicles

D.3.7 Modal Split

The modal split of person trips was determined before input to the model, i.e. before distribution; person trips by auto and by transit were specified as different "commodities". Supply and demand nodes were normally located directly on highway links; transfers between highway and other modes were allowed or suppressed for each commodity as required, e.g., only transit person trips were allowed to travel on subway and commuter rail links.

D.3.8 Link Characteristics and Cost Models

Because of the limitations on the number of zones and the number of links, the analysis was performed on the basis of a travel corridor network, the links being corridors forming direct connections between adjacent zone centroids.

Since a highway link connecting two centroids generally represented a combination of several facilities of different types (e.g. arterials and expressways), evaluation of the composite characteristics was necessary to calculate travel times and evaluate congestion effects. The relatively sophisticated highway cost sub-model which is built into TRANS, was replaced by a simpler model which applied a volume-capacity relationship to the free speed and the assigned volume to give a congestion-limited speed, which was then used in the subsequent distribution-assignment procedure. The new highway cost sub-model was also used to apply a simple relationship to calculate the operating costs of the different types of vehicle using the link in question.

D.3.9 Minimum Path Criteria

The TRANS model performs distribution and assignment on the basis of minimum cost routes, where the cost consists of a specified combination of the costs of (a) waiting time (b) travel time (c) uncertainty of arrival (d) loss or damage (e.g. accidents) and (e) out-of-pocket cost to goods shipper or passenger. In this study, the distribution and assignments were based on minimum time paths only, by applying an arbitrary value to the travel time only. Travel cost was calculated but not used as a distribution parameter.

D.3.10 Directional Vehicle Equalization

The TRANS model accumulates the flows of each commodity according to its vehicle type on to the link network. When all commodities have been assigned, the total volume using each vehicle class on each link is converted to a number of vehicles, using a

payload or occupany factor. As originally written, the TRANS model takes the number of vehicles in the direction of heavier flow, and makes the number of vehicles in the opposite direction the same. This procedure required modification for this study because the time period being dealt with was an hour, rather than a day as in the original model. In the simulation of one-way flows during each period (e.g., a.m. peak flows) the balancing continued to be applied to transit travel, as transit vehicles generally return to their point of origin over the same route. However, the program has been modified so that this balancing was not performed in the case of auto and truck travel, as most autos and trucks do not return to their point of origin within the same time period.

D.3.11 Output

The TRANS model has provisions for providing a great variety of output, including commodity supply and demand tables, origin-destination costs and flows, and details of the link characteristics, link utilization (tons, vehicles,turns) and link performance (waiting time, travel time, etc.).

In this study much of the possible output has been suppressed and only a minimum printed out. The number of commodities is considerably less than in the Dahomey Study, reducing the number of O-D tables; also the link output has been restricted to link characteristics, link flows in vehicles, and link travel time and operating cost by vehicle type.

D.4 FUTURE MODEL DEVELOPMENT

The present state of the art with regard to urban transport models leaves much room for improvement. However, much valuable information is being gained from the widespread use of the current equalibrium transport models. The complexity of the urban area is such, however, that it will be extremely difficult to predict the results of various policy options in the transportation and urban planning field without the use of a dynamic model which deals with the Social and Economic Cities as well as the Physical and Demographic Cities.

A major interdisciplinary effort, involving engineers, economists, marketing specialists and others will be required over the coming years to produce models that accurately represent (a) consumer demand for transport, (b) the social and financial costs of supplying same and (c) the final equilibrium point or level of usage.

D.5 SUMMARY

The urban area is a very complex organism, the workings of which can probably only be understood by the use of a modelling approach. A comprehensive urban model is beyond our present capabilities, but the transport subsystem has been modelled quite successfully and has proved very useful in facility design and the evaluation of alternative transport systems and city forms.

Present urban transport models, however, have some significant deficiencies, particularly regarding goods movements and estimation of costs and benefits.

A review was made of currently available models for possible use in this study. This review found that the TRANS model was the most suitable model to use: it could be run at reasonable cost, it considers freight movements as well as person movements, it makes possible the evaluation of alternative land use plans and transport systems, and it is readily available and proven in operation.

The characteristics of TRANS and how it was modified for this application are described.

APPENDIX E

SUPPLEMENTARY TABLES

Et1	1966 POPULATION & EMPLOYMENT DISTRIBUTION - CITY A
Et2	1966 POPULATION & EMPLOYMENT DISTRIBUTION - CITY B
Et3	1966 POPULATION & EMPLOYMENT DISTRIBUTION - CITY C
Et4	2001 POPULATION & EMPLOYMENT DISTRIBUTION - CITY A
Et5	2001 POPULATION & EMPLOYMENT DISTRIBUTION - CITY B
Et6	2001 POPULATION & EMPLOYMENT DISTRIBUTION - CITY C
Et7	LINK CHARACTERISTICS - CITY A
Et8	LINK CHARACTERISTICS - CITY B
Et9	LINK CHARACTERISTICS - CITY C
Et10	PERSON TRIP GENERATION - CITY A - 1966
Et11	GOODS TRIP GENERATION - CITY A - 1966

TABLE Et1

1966 POPULATION & EMPLOYMENT DISTRIBUTION - CITY A

	ZONE	POPU-LATION	EMPLOYMENT RETAIL	OTHER COMMERCIAL	PUBLIC & SEMI-PUBLIC	INDUSTRIAL	TOTAL
Airport	1	0	0	0	250	1,500	1,750
	2	3,500	140	320	450	2,210	3,120
	3	11,900	460	1,090	540	1,650	3,740
	4	5,400	210	480	390	1,710	2,790
	5	3,400	130	310	100	140	680
	6	18,700	730	1,710	810	2,400	5,650
	7	10,900	430	990	540	1,810	3,770
University	8	0	0	0	1,500	0	1,500
	9	3,500	140	320	370	1,760	2,590
	10	12,600	490	1,150	530	1,520	3,690
C.B.D.	11	1,800	3,500	8,100	1,300	1,000	13,900
	12	7,300	290	670	210	300	1,470
	13	15,200	590	1,390	440	620	3,040
	14	3,100	120	280	90	130	620
	15	6,800	270	620	370	1,290	2,550
	16	5,600	220	510	250	750	1,730
	17	5,300	210	480	150	220	1,060
TOTAL URBAN		115,000	7,930	18,420	8,290	19,010	53,650
OUTSIDE URBANIZED AREA		10,000					
TOTAL METRO		125,000					

TABLE Et2

1966 POPULATION & EMPLOYMENT DISTRIBUTION - CITY B

	ZONE	POPULATION	EMPLOYMENT: RETAIL	OTHER COMMERCIAL	PUBLIC & SEMI-PUBLIC	INDUSTRIAL	TOTAL
	1	0	0	0	400	2,000	2,400
	2	0	0	0	400	1,700	2,100
	3	0	0	0	600	2,800	3,400
	4	4,000	200	400	200	200	1,000
	5	19,700	800	1,800	1,800	5,900	10,300
	6	34,100	1,400	3,100	1,300	1,400	7,200
	7	28,600	1,100	2,600	3,000	10,300	17,000
	8	18,700	700	1,700	1,300	3,900	7,600
	9	60,900	7,400	5,600	3,200	7,000	18,200
C.B.D.	10	5,500	11,200	26,200	4,700	3,800	45,900
	11	48,100	2,900	4,400	3,300	8,300	18,900
	12	14,600	600	1,300	900	7,200	5,000
	13	19,000	800	1,800	700	800	4,100
	14	7,200	300	600	900	3,300	5,100
	15	0	0	0	800	3,800	4,600
	16	43,700	1,800	4,000	2,100	4,300	12,200
	17	73,500	2,900	6,800	2,700	3,000	15,400
	18	43,300	1,700	4,000	1,600	1,700	9,000
	19	20,700	800	1,900	1,400	4,000	8,100
TOTAL URBAN		441,600	29,600	66,200	31,300	70,400	197,500
OUTSIDE URBANIZED AREA		58,400					
TOTAL METRO		500,000					

TABLE Et3

1966 POPULATION & EMPLOYMENT DISTRIBUTION - CITY C

ZONE	POPU-LATION	EMPLOYMENT				
		RETAIL	OTHER COMMERCIAL	PUBLIC & SEMI-PUBLIC	INDUSTRIAL	TOTAL
1	2,900	110	330	340	1,280	2,060
2	6,900	270	780	260	280	1,510
3	12,800	500	1,440	1,510	5,710	9,160
4	47,500	1,850	5,340	3,300	9,580	20,070
5	9,800	380	1,110	370	390	2,240
6	43,700	1,700	4,910	1,650	1,750	10,010
7	33,400	2,800	3,760	5,460	20,160	33,180
8	0	0	0	2,070	10,500	12,570
9	22,600	8,800	2,540	850	900	5,170
10	12,200	4,700	1,370	920	2,840	5,600
11	0	0	0	730	3,700	4,420
12	148,200	8,760	16,700	6,180	5,930	37,570
13	120,000	4,670	13,500	8,710	26,070	57,950
14	181,900	8,580	20,450	7,150	7,270	43,450
15	87,100	3,390	9,800	6,400	19,310	38,900
16	36,900	1,430	4,150	3,510	12,250	21,340
17	6,900	270	780	620	2,060	3,720
18	0	0	0	2,060	10,500	12,570
19	244,900	10,330	27,580	9,400	9,800	57,110
20	55,100	2,140	6,200	10,210	43,500	62,050
21	324,800	12,630	36,550	12,250	13,000	74,430
22	10,000	39,200	96,000	19,000	14,800	169,000
23	184,700	7,180	20,780	6,960	7,380	42,300
24	227,600	8,850	25,600	9,260	12,560	56,270
25	36,500	3,420	4,110	6,360	24,760	38,650
26	32,000	1,240	3,600	1,200	1,280	7,320
TOTAL URBAN	1,888,400	122,050	307,370	126,730	267,560	823,700
OUTSIDE URBAN AREA	111,600					
TOTAL METRO	2,000,000					

TABLE Et4

2001 POPULATION & EMPLOYMENT DISTRIBUTION - CITY A

ZONE	POPULATION	EMPLOYMENT				
		RETAIL	OTHER COMMERCIAL	PUBLIC & SEMI-PUBLIC	INDUSTRIAL	TOTAL
1	0	0	0	440	2,660	3,100
2	20,600	820	1,890	2,650	13,010	18,370
3	42,200	1,630	3,870	1,920	5,850	13,270
4	23,200	900	2,060	1,680	7,350	11,990
5	15,500	590	1,410	460	640	3,100
6	11,300	1,290	3,030	1,430	4,250	10,000
7	13,800	550	1,250	680	2,290	4,770
8	1,900	0	0	2,650	0	2,650
9	15,800	630	1,450	1,670	7,950	11,700
10	19,700	760	1,800	830	2,380	5,770
11	1,800	3,500	8,100	1,300	1,000	13,900
12	9,300	370	850	270	380	1,870
13	15,900	620	1,450	460	650	3,180
14	17,700	690	1,600	510	740	3,540
15	25,100	1,000	2,290	1,370	4,750	9,410
16	12,900	510	1,180	570	1,730	3,990
17	19,300	760	1,750	550	800	3,860
TOTAL URBAN	266,000	14,620	33,980	68,040	56,430	124,470
OUTSIDE URBAN AREA	24,000					
TOTAL METRO	290,000					

TABLE Et5

2001 POPULATION & EMPLOYMENT DISTRIBUTION - CITY B

ZONE	POPULATION	EMPLOYMENT				
		RETAIL	OTHER COMMERCIAL	PUBLIC & SEMI-PUBLIC	INDUSTRIAL	TOTAL
1	0	0	0	2,500	12,400	14,900
2	0	0	0	2,700	11,400	14,100
3	0	0	0	3,100	14,300	17,400
4	39,100	2,000	3,800	2,000	2,000	9,800
5	105,300	4,900	9,300	9,300	31,100	54,600
6	53,100	2,200	5,000	2,100	2,200	11,500
7	42,100	1,800	3,800	4,600	15,300	25,500
8	38,500	1,600	3,500	2,700	8,100	15,900
9	83,700	3,600	7,400	4,300	9,700	25,500
10	5,500	11,200	26,200	4,700	3,800	45,900
11	87,900	5,400	7,800	5,800	15,000	34,000
12	95,000	4,000	8,400	5,800	14,300	32,500
13	56,800	2,400	5,400	2,100	2,400	12,300
14	62,100	2,200	5,300	7,900	28,500	43,900
15	0	0	0	3,500	16,900	20,400
16	115,100	4,700	10,500	5,400	11,100	31,700
17	106,400	4,300	9,500	3,700	4,100	21,600
18	128,500	5,100	11,900	4,900	5,100	27,000
19	73,900	3,200	6,700	5,000	14,300	29,200
TOTAL URBAN	1,093,000	58,600	125,000	82,100	222,000	487,700
OUTSIDE URBANIZED AREA	127,000					
TOTAL METRO	1,220,000					

TABLE Et6

2001 POPULATION & EMPLOYMENT DISTRIBUTION - CITY C

ZONE	POPU-LATION	EMPLOYMENT RETAIL	OTHER COMMERCIAL	PUBLIC & SEMI-PUBLIC	INDUSTRIAL	TOTAL
1	78,300	3,800	11,700	8,600	25,400	49,500
2	148,100	7,400	21,900	5,200	4,400	38,900
3	152,700	7,600	22,500	16,900	50,000	97,000
4	285,200	14,000	41,900	18,600	42,200	116,700
5	335,100	16,500	49,600	11,900	9,800	87,800
6	96,000	4,700	14,100	3,400	2,800	25,000
7	291,300	31,000	42,900	44,600	129,100	247,600
8	93,000	4,600	13,700	5,400	21,500	45,200
9	197,400	9,800	29,000	7,000	5,800	51,600
10	195,900	9,600	28,800	13,800	33,500	85,700
11	0	0	0	1,900	7,600	9,500
12	650,400	48,700	95,900	25,400	19,100	189,100
13	167,400	8,300	24,600	11,400	26,700	71,000
14	255,800	15,300	37,600	9,400	7,500	69,800
15	259,400	12,800	38,200	17,900	42,200	111,100
16	80,300	3,900	11,800	7,200	19,600	42,500
17	346,600	17,200	51,200	29,200	76,000	173,600
18	0	0	0	5,400	21,500	26,900
19	340,600	18,200	50,100	12,200	10,000	90,500
20	145,500	7,200	21,400	25,200	84,300	138,100
21	324,800	12,100	36,100	8,700	7,200	64,100
22	10,000	39,200	96,000	19,000	14,800	169,000
23	219,300	10,800	32,200	7,700	6,400	57,100
24	416,900	20,600	61,300	15,900	16,900	114,700
25	140,000	16,600	20,600	22,800	69,700	129,700
26	114,300	5,600	16,800	4,000	3,400	29,800
TOTAL URBAN	5,344,300	345,300	869,900	358,700	757,400	2,331,500
OUTSIDE URBANIZED AREA	215,700					
TOTAL METRO	5,560,000					

TABLE Et7

LINK CHARACTERISTICS - CITY A

LINK	LENGTH (MI.)	1966 CHAR-ACTERISTICS	2001 CHAR-ACTERISTICS
1-22	.8	A2/40	A
2-22	.6	A2/30	A
2-23	.5	A2/30	A
3- 8	1.4	A2/35	A
3-24	1.0	A2/35	A
4- 5	1.2	A2/35	A
4-31	1.1	A2/35	A
5- 6	.7	A4/30	A
5-32	1.1	A4/30	A
6-25	.6	A4/30	A
6-33	1.2	A4/30	A
7-26	.5	A4/30	A
7-27	.4	A2/30	A
7-29	.9	A2/30	A
8-14	1.1	A2/35	A
8-30	1.1	A4/35	A
8-41	1.1	A2/35	A
9-31	.5	A2/35	A
9-36	1.8	A2/35	A
10-33	.6	A4/30	A
10-37	.5	A4/30	A
11-12	.4	A4/20	A
11-28	.5	A6/20	A
11-33	.8	A6/25	A
11-34	.3	A6/20	A
12-29	.5	A2/25	A
12-35	.4	A2/25	A
13-30	1.0	A2/30	A
13-35	.5	A4/30	A
13-40	.7	A4/30	A
14-42	1.1	A2/35	A
15-36	.5	A2/30	A
15-43	1.1	A2/30	A
15-45		-	A
16-17	.6	A2/35	A
16-39	.5	A4/30	A

LINK	LENGTH (MI.)	1966 CHAR-ACTERISTICS	2001 ACTERISTICS
16-43	1.7	A4/30	A
17-41	.6	A2/35	A
17-47		-	A
18-35	2.0	F4/50	F
19-44	2.0	A4/40	A
44-23			A
20-42	2.0	A4/40	F
21-46	2.0	F4/50	F
46-43			F
22-25	.7	A2/35	A
22-31		-	F
22-44		-	F
23-24	.9	A2/30	A
23-26	.5	A4/30	A
24-27	.7	A2/30	A
24-42		-	A
24-44		-	A
25-26	.9	A4/30	A
26-28	.9	A4/30	A
27-30	.9	A2/30	A
28-29	.4	A4/30	A
29-30	.4	A4/30	A
31-32	1.2	A4/35	A
31-46		-	F
32-33	.7	A6/30	A
32-36	1.1	A4/30	A
34-35	.4	A4/25	A
34-38	.8	A4/30	F
35-39	.5	A4/30	A
36-37	.7	A4/30	A
37-38	.4	A4/30	A
38-43	.5	A4/30	F
39-40	1.1	A2/30	A
40-41	.6	A4/30	F
41-42	1.1	A4/40	F
42-47		-	F
45-46		-	F
46-47		-	F

For explanatory notes, see page following Table Et9.

TABLE Et8

LINK CHARACTERISTICS - CITY B

LINK	LENGTH (MI.)	1966 CHARACTERISTICS	2001 CHARACTERISTICS NEUTRAL PATH & FINE GRAIN	PROGRAMMED MODULE	OPTIMUM SPACING
1- 6	1.6	A4/40	A4/40	P	A8/40
2-26	1.2	A4/40	A4/40		A4/40
2-27	1.2	--	A4/40		A4/40
2-28	1.2	A4/40	A4/40	P	A4/40
3- 4	1.1	A2/40	A2/40	P	A8/40
3-12	3.3	F4/60	F4/60		F4/60
3-26	3.5	F4/60	F4/60		F4/60
3-29	2.3	A4/40	A4/40	P	A4/40
5-25	4.7	A4/50	A4/50		A6/50
5-30	0.9	A6/40	A6/40	P	A8/40
6-25	6.4	A2/40	A2/40		A6/40
6-27	1.2	A4/40	A4/40		A4/40
6-28	1.1	A4/40	A4/40	P	A4/40
6-45	2.2	A6/35	A6/35	P	A6/35
7-30	2.1	A6/35	A6/35	P	A6/35
7-35	0.7	A4/30	A4/30	P	A4/30
7-49	0.5	A8/30	A8/30	P	A12/30
8-28	1.1	A6/40	A6/40	P	A6/40
8-29	1.2	A6/35	A6/35	P	A6/35
8-46	2.0	A6/30	A6/30		A6/30
9-10	0.8	A6/20	A8/20	P	A8/20
9-31	0.4	A8/25	A8/25	P	A12/25
9-32	2.0	A8/30	A10/30	P	A12/30
9-46	0.8	A6/30	A8/30		A8/30
10-36	0.4	A10/20	A12/20	P	A12/20
10-37	1.7	A10/25	A12/25		A12/25
10-41	0.4	A6/25	A6/25	P	A6/25
11-19	1.3	A4/30	A4/30	P	A4/30
11-32	1.2	A8/30	A8/30	P	A10/30
11-33	1.2	A6/30	A6/30	P	A6/30
11-48	0.7	A6/35	A6/35		A6/35
12-33	1.3	A4/40	A4/40	P	A4/40
12-48	2.5	--	A4/40		F6/60
12-54	1.0	--	F4/60		F4/60
13-34	1.5	A4/40	A4/40	P	A4/40
13-39	0.9	A4/40	A4/40	P	A4/40
13-55	1.0	--	A4/40		A4/40
14-15	3.2	A4/40	A4/40	P	A4/40
14-24	1.5	A2/50	A2/50		A6/50
14-43	3.9	A4/50	A4/50		A4/50
15-39	0.6	A4/40	A4/40	P	A4/40
15-40	1.8	A4/40	A4/40		A4/40
16-41	1.4	A6/35	A6/35	P	A6/35
16-43	2.2	A4/40	A4/40		A4/40

--- continued

Table Et8 (cont.)

LINK	LENGTH (MI.)	1966 CHARACTERISTICS	2001 CHARACTERISTICS		
			NEUTRAL PATH & FINE GRAIN	PROGRAMMED MODULE	OPTIMUM SPACING
16-52	0.5	A6/50	A6/50		A6/50
17-41	0.9	A6/30	A6/30	P	A6/30
17-42	1.4	A4/30	A4/30	P	A4/30
18-23	2.4	A4/50	A4/50		A6/50
18-44	2.9	A4/40	A4/40		A4/40
18-53	0.8	A4/40	A4/40	P	A4/40
19-22	5.1	A4/40	A4/40		A6/40
19-33	1.1	A4/30	A4/30		A4/30
19-37	2.4	A8/30	A10/30		A10/30
19-44	2.2	A4/40	A4/40		A4/40
19-53	2.2	--	F6/60		F6/60
19-54	2.0	--	F4/60		F4/60
20-26	0.4	F4/60	F4/60		F4/60
20-27	1.6	F6/60	F6/60		F6/60
21-54	2.8	F4/60	F4/60		A6/60
22-44	4.1	A2/45	A2/45		A4/45
23-52	3.8	A6/50	A6/50		A6/50
24/38	3.3	F4/60	F4/60		F4/60
24-51	5.7	--	F4/60		F4/60
27-30	3.8	A6/60	A6/60		A6/60
27-56	5.4	--	--	--	A6/60
29-47	1.0	A4/30	A4/30	P	A4/30
29-48	1.0	A6/35	A6/35		A6/35
30-49	2.5	--	A6/60		--
30-56	2.3	--	--	--	A6/60
30-55	2.5	A4/60	A4/60		A4/60
31-36	0.8	A6/25	A8/25		A8/25
31-45	0.9	A6/35	A8/35	P	A8/35
31-49	0.2	A8/30	A10/30	P	A12/30
32-37	0.9	A4/30	A4/30	P	A4/30
32-47	0.3	A4/30	A4/30	P	A4/30
34-35	1.0	A6/30	A6/30	P	A6/30
34-39	1.5	A4/40	A4/40		A4/40
34-40	1.0	A4/40	A4/40		A4/40
35-50	0.5	A8/25	A8/25	P	A12/25
36-40	2.1	A6/30	A6/30		A6/30
36-41	0.6	A6/25	A6/25		A6/25
36-50	0.3	A8/25	A10/25	P	A12/25
37-42	1.4	A4/30	A4/30	P	A4/30
38-39	2.3	A4/50	A4/50		A4/50
38-55	2.4	F4/60	F4/60		F4/60
40-43	1.0	A4/40	A4/40		A4/40
42-53	0.2	A4/40	A4/40	P	A4/40
45-46	0.5	A4/30	A4/30		A4/30
46-47	1.7	--	A4/35		A4/35
46-48	2.3	--	--	--	F6/60
46-56	0.9	--	--	--	F6/60
47-48	0.6	--	A4/40		A4/40
49-56	0.9	--	--	--	F6/60
50-51	2.4	--	F6/60		F6/60
51-52	1.0	--	F6/60		F6/60
52-53	1.7	--	F6/60		F6/60

TABLE Et9

LINK CHARACTERISTICS - CITY C

LINK	LENGTH (MI.)	1966 CHAR-ACTERISTICS	LINK	LENGTH (MI.)	1966 CHAR-ACTERISTICS
1-2	3.4	A4/50	17-85	3.1	A2/40
2-45	1.9	A4/40 *	18-19	3.7	A6/30
2-59	7.7	A4/40	18-60	2.1	A6/30
3-28	4.0	A4/40	18-69	0.9	A4/30
3-39	4.1	A6/35	18-78	0.6	A6/30
3-45	6.6	A4/40	19-62	2.3	F6/50
3-46	1.9	A4/40	19-70	1.4	A6/30
4-34	5.0	A4/40	19-80	1.1	A6/30 *
4-39	1.4	A6/35	20-79	2.1	A6/40 *
4-40	2.6	A6/30	20-80	0.4	A6/25 *
4-48	1.6	A4/35	20-90	2.6	A6/40 *
5-6	4.9	A6/35	21-64	2.0	A8/25
5-34	1.4	A4/35 *	21-70	0.9	A6/25
5-35	2.1	A4/35 *	21-71	0.9	A6/25
6-14	2.1	A6/30	21-72	0.5	A8/25
6-40	0.7	A6/30	22-72	0.7	A8/20
6-41	1.2	A6/30	22-81	1.0	A8/20
7-8	6.1	A4/40	22-82	0.9	A8/20
7-42	0.2	A6/30	22-86	0.7	A4/20
7-43	3.7	A6/35	23-24	2.7	A6/25
7-53	2.2	A4/35	23-74	1.0	A6/25
8-35	1.8	A4/40 *	23-82	1.6	A8/25
8-36	3.8	A4/40 *	23-88	1.0	A4/25
9-43	0.5	A6/35	24-75	0.7	A4/30
9-44	2.0	A6/35	24-83	1.2	A6/30
9-54	2.6	A4/35	24-89	0.6	A4/30
10-37	4.0	A4/50 *	25-26	2.6	A4/35
10-38	5.2	A4/50 *	25-93	3.3	A4/30
11-57	1.9	F4/50	25-96	1.4	A4/30
12-59	1.3	A4/40	26-97	0.9	A4/35
12-60	2.9	A6/35	27-45	5.4	F6/60
12-69	3.1	A4/40	28-33	4.9	A4/40 *
13-48	1.2	A4/30	29-35	4.3	F4/60
13-61	1.3	A4/30	30-38	2.6	A4/50 *
14-50	0.9	F8/60	30-58	2.8	F4/60
14-51	0.9	F8/60	31-85	3.8	A2/50
14-64	2.0	A8/30	32-97	2.4	F4/60
15-54	1.2	A4/35	33-34	2.3	A4/40 *
15-67	0.8	A6/30	33-39	4.4	A4/40
15-68	1.1	A6/30	35-42	5.6	F4/60
15-75	1.7	A4/30	36-37	2.7	F4/40 *
16-56	1.1	A4/40	37-44	2.6	A4/40
16-68	1.1	A6/35	38-58	1.2	A2/40
16-77	1.7	A4/35	39-47	1.4	A4/35
17-58	0.7	A2/40	40-50	2.0	A4/30

* See Note (1)

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Table Et9 (cont.)

LINK	LENGTH (MI.)	1966 CHAR-ACTERISTICS	LINK	LENGTH (MI.)	1966 CHAR-ACTERISTICS
41-42	1.1	A6/30	78-79	0.9	A6/30
41-51	2.0	A6/30	79-80	1.9	A6/30
42-52	2.1	F4/60	80-81	1.6	A8/25
44-56	2.1	A4/40	82-87	0.7	A6/25
45-46	7.3	F6/60	83-84	1.0	A6/30
46-47	3.7	F6/60	83-95	1.8	F4/50
46-59	2.2	A4/40	84-85	4.5	A4/40
47-48	1.7	F6/60	84-96	1.7	A4/35
47-60	3.1	A6/35	85-97	3.4	A4/40
48-49	0.9	F8/60	86-87	0.9	A6/25
49-50	1.6	F8/60	86-90	0.3	A4/25
49-62	2.1	F6/50	87-88	1.8	A6/30
50-63	0.9	A6/30	87-91	0.3	A6/25
51-52	0.9	F8/60	88-92	0.2	A4/25
51-65	1.9	A6/30	88-93	2.1	A6/30
52-53	0.6	F8/60	89-94	1.6	A4/30
53-54	3.4	F8/60	90-91	1.2	F6/50
53-66	1.5	A6/30	91-92	1.7	F6/50
54-55	1.1	F8/60	92-93	1.8	F6/50
55-56	1.1	F6/60	93-94	0.6	F6/50
55-68	1.2	F4/50	94-95	1.9	F6/50
56-57	2.1	F6/60	95-96	0.3	F6/60
57-58	4.8	F4/60	96-97	3.4	F6/60
60-61	1.5	A6/35			
61-62	1.2	A6/30			
62-63	1.4	A6/30			
63-64	1.2	A6/30			
63-70	2.1	A6/30			
64-65	1.0	A6/30			
65-66	1.4	A6/30			
65-71	2.0	A6/30			
66-67	2.3	A6/30			
66-74	1.7	A6/30			
68-76	1.6	F4/50			
69-78	1.3	A4/30			
70-81	1.4	A6/25			
71-73	0.2	A8/25			
72-73	1.0	A6/25			
73-74	1.4	A6/30			
73-82	1.2	A6/25			
74-75	2.9	A6/30			
75-76	0.9	A6/30			
76-77	1.1	A4/30			
76-83	0.7	F4/50			
77-84	0.7	A4/35			

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LINK CHARACTERISTICS - CITY C (continued)

TRANSFER LINKS			RAIL LINKS		
LINK	LENGTH (MI.)	1966 CHAR-ACTERISTICS	LINK	LENGTH (MI.)	1966 CHAR-ACTERISTICS
38-110	-	10/2	98-99	1.4	5/20
43-113	-	10/2	99-100	2.1	5/20
64-110	-	2/1	100-101	2.0	5/20
67-112	-	10/2	102-103	3.2	R/40
78-105	-	10/2	103-104	9.1	R/45
84-109	-	10/2	104-105	4.3	R/35
89-108	-	10/2	105-106	3.8	R/30
			106-107	3.1	R/30
			107-108	5.4	R/35
			108-109	2.2	R/35
			109-110	8.7	R/45
			111-112	5.8	R/35
			112-113	3.9	R/35
			113-114	3.8	R/40

NOTES:

(1) Future network not drawn up in detail for this city. Links indicated * would be classified as freeways in 2001, together with other links not shown.

(2) Road links: A4/30 indicates 4-lane arterial with 30 mph free speed.
F6/60 indicates 6-lane freeway with 60 mph free speed.

(3) Transfer links: 10/2 indicates 10 min. transfer time in forward direction of link, 2 min. in reverse direction.

(4) Rail links: 5/20 indicates subway with speed of 20 mph; R indicates commuter rail.

TABLE Et10

PERSON TRIP GENERATION - CITY A - 1966

ZONE	TRANSIT WORK		TRANSIT NON-WORK		AUTO WORK		AUTO NON-WORK		EXTERNAL (AUTO)	
	P	A	P	A	P	A	P	A	P	A
1	0	170	0	50	0	1,360	0	440	-	570
2	160	290	250	180	1,210	2,340	1,820	1,600	-	980
3	560	340	840	420	4,130	2,790	6,190	3,680	-	1,170
4	250	260	380	220	1,870	2,110	2,810	1,900	-	890
5	160	60	240	110	1,180	530	1,770	950	-	220
6	880	520	1,330	650	6,490	4,220	9,720	5,720	-	1,770
7	510	350	770	390	3,780	2,860	5,670	3,450	-	1,210
8	0	140	0	300	0	1,130	0	2,640	-	470
9	160	240	250	170	1,210	1,960	1,820	1,460	-	820
10	590	340	890	430	4,370	2,790	6,550	3,810	-	1,170
11	80	1,760	130	3,800	620	9,880	940	21,530	-	4,410
12	340	140	520	230	2,530	1,130	3,800	2,060	-	480
13	720	280	1,080	480	5,270	2,260	7,900	4,260	-	950
14	150	50	220	100	1,070	450	1,610	860	-	190
15	320	230	480	250	2,360	1,880	3,540	2,220	-	790
16	260	160	400	200	1,940	1,280	2,910	1,720	-	540
17	250	100	380	170	1,840	830	2,760	1,480	-	350
18	-	-	-	-	-	-	-	-	5,660	-
19	-	-	-	-	-	-	-	-	2,830	-
20	-	-	-	-	-	-	-	-	2,830	-
21	-	-	-	-	-	-	-	-	5,660	-
TOTAL	5,390	5,430	8,160	8,150	39,870	39,800	59,810	59,780	16,980	16,980
PEAK/ Off-Pk. Split	48/52		26/74		56/44		30/70		40/60	

NOTES:
(1) P = Trips Produced, A = Trips attracted
(2) Values represent half-day trips; it is assumed that over a 24-hour period each trip will be matched by a return trip in the opposite direction.
(3) Attractions were adjusted by program to equal total productions.

TABLE Et11

GOODS TRIP GENERATION - CITY A - 1966

ZONE	LOCAL (GENERAL) GOODS		LOCAL (BULK) GOODS		EXTERNAL (BULK) GOODS	
	P	A	P	A	P	A
1	14	14	237	237	-	143
2	43	43	411	411	-	247
3	82	82	490	490	-	294
4	49	49	372	372	-	223
5	22	22	93	93	-	56
6	139	139	676	676	-	445
7	84	84	505	505	-	303
8	29	29	199	199	-	119
9	38	38	345	345	-	207
10	92	92	492	492	-	295
11	183	183	1,842	1,842	-	1,106
12	48	48	199	199	-	119
13	100	100	398	398	-	239
14	20	20	80	80	-	48
15	55	55	332	332	-	199
16	42	42	225	225	-	135
17	34	34	146	146	-	87
18	-	-	-	-	1,420	-
19	-	-	-	-	710	-
20	-	-	-	-	710	-
21	-	-	-	-	1,420	-
TOTAL	1,074	1,074	7,042	7,042	4,240	4,265
Peak/ Off-Pk. Split	30/70		30/70		30/70	

NOTES:
(1) P=Tons produced, A = Tons Attracted
(2) Values are in tons of goods; average load of light trucks (general goods) 0.104 tons; average load of heavy trucks (bulk goods) 2.05 tons.
(3) Values are for half-day; system measures were doubled to obtain whole day.
(4) Attractions were adjusted by program to equal total productions.

REFERENCES

(1) N. D. Lea & Associates Ltd. "Urban Transportation Developments in Eleven Canadian Metropolitan Areas". Ottawa, Canadian Good Roads Association, September 1966.

(2) Lea, N.D. "Toward Understanding Urban Transportation" Advance position paper for the Canadian Federation of Mayors and Municipalities, 1969 Urban Transportation Conference.

(3) Tanton, M.S. and Lea, N.D. "Population, Prosperity and Transportation". Presented at the 2nd annual meeting of the Canadian Transportation Research Forum, Sept. 1966.

(4) Stowers and Kanwit. "The Use of Behavioural Surveys in Forecasting Transportation Requirements". Highway Research Board, Record Number 106, Washington, D.C. 1966.

(5) Comprehensive Planning Office - The Port of New York Authority, "Metropolitan Transportation - 1980". New York, 1963.

(6) Lithwick, N.H. and Paquet, Giles "Urban Studies - A Canadian Perspective", Toronto, Methuen, 1968.

(7) American Society of Civil Engineers. "Urban Planning Guide". New York, 1969 (Manual No. 49) A.S.C.E.

(8) Ewalt Jr., W.R. Ed. "Environment and Policy: The Next Fifty Years" - Bloomington, Indiana, University Press, 1968.

(9) U.S. Department of Health, Education and Welfare. "Toward a Social Report". Washington, D.C., U.S. Government, Printing Office, 1969.

(10) Department of Transport, Canada. "The Role of the Federal Government in Urban Transport", 1968.

(11) Stone, Leroy O. "Urban Development in Canada". Ottawa, Dominion Bureau of Statistics, 1967 (one of a series of 1961 census monographs).

(12) Corthell, E.L. "Growth and Density of Population of Great Cities" - American Association for the Advancement of Science 1903.

(13) Price, Derek J. De Solla. "Little Science, Big Science". New York, Columbia University Press, 1963.

(14) Lea, N.D. "The Hour of Destiny for Engineering". An address delivered to the first principal's dinner of N.D. Lea and Associates Ltd., March 1963.

(15) Canadian Federation of Mayors and Municipalities. First Canadian urban transportation conference - "Proceedings", "Regional Study Papers", "Compilation of Articles", "Study Papers". Toronto, 1969.

(16) Canadian Federation of Mayors and Municipalities. First Canadian urban transportation conference - Policy Statement. Toronto, 1969.

(17) Lewis, D. Beaumont. "The Prospect for Urban Mobility" York University, 1969.

(18) Dominion Bureau of Statistics. 1964 Urban Family Expenditure Survey. (Cat. No. 62-527).

(19) Financial Post. "Survey of Markets and Business Year Book", Toronto, Maclean Hunter, 1968-69.

(20) Dominion Bureau of Statistics. "Motor Transport Traffic, Canada, 1964". 1967 (Cat. No. 53-207).

(21) Dominion Bureau of Statistics. "Motor Carriers - Freight, 1966". Parts 1 and 2, 1968 (Cat No. 53-222 and 53-223).

(22) Dominion Bureau of Statistics. "The Motor Vehicle 1967", Part III, 1969 (Cat. 53-219).

(23) Bauer, Raymond A. Ed., "Social Indicators", Cambridge, Mass. M.I.T. Press, 1966.

(24) Hill, M. "Goals Achievement Matrix for Evaluating Alternative Plans".

(25) Building Research Station (U.K.). "London Noise Survey", London, Her Majesty's Stationery Office, 1968.

(26) Sullivan, J.L., "Air Pollution and the Motor Vehicle", Canadian Good Roads Association, September 1968.

(27) Lipsey, R., "Introduction to Positive Economics".

(28) Robbins, L., "Nature and Significance of Economic Studies".

(29) Dominion Bureau of Statistics, 1961 Census of Canada, "Population Rural and Urban Distribution, 1966", (Cat. No. 92-536).

(30) Manning, E.C., "A White Paper on Human Resources Development". Edmonton, Queen's Printer, 1967.

(31) U.S. Dept. of Housing and Urban Development. "Tomorrow's Transportation: New Systems for the Urban Future". Washington D.C., U.S. Government Printing Office, 1968.

(32) Cornell Aeronautical Laboratory Inc., "Metrotrans - 2000 A Study of Future Concepts in Metropolitan Transportation for the Year 2000". Buffalo, Cornell University, 1968.

(33) Hayman, Robert A. and others. "Bi-modal Urban Transportation System Study". Buffalo, Cornell Aeronautical Laboratories Incorporated, 1968.

(34) Ayres, Robert U. and McKenna,Richard A., "Technology and Urban Transportation: Environmental Quality Considerations". Croton-on-Hudson, Hudson Institute, 1968 2 vol. - Review Draft Not For Publication.

(35) "Project Metran: An Integrated, Evolutionary Transportation System for Urban Affairs". Interdepartmental student project in systems engineering. Cambridge, Mass., Tm. I.T. Press, 1966 (M.I.T. Report No. 8).

(36) Institute of Mechanical Engineers. "Guided Land Transport Convention", London 1966.

(37) N. D. Lea & Associates Ltd., "Transportation Corridors", report to C.M.H.C. December, 1969.

(38) N. D. Lea & Associates Ltd. Technical Memoranda suplementry to ref. (37) 1968, T.M.
T.M. 1 - Urban Form and Transportation
T.M. 2 - Transportation Technology
T.M. 3 - Transportation Corridor Cost - Benefit Analysis
T.M. 4 - Urban Boundaries and Corridor Costs.

(39) Westinghouse and Consortium., "Study of Evolutionary Urban Transport". Final Report and 4 Appendices to HUD 1968.

(40) Henderson, Clark and others. "Future Urban Transportation Systems: Descriptions, Evaluations and Programmes". Menlo Park, California, Stanford, Research Institute, 1968. Final Report #1. The most significant of the HUD reports and that upon which most of Ref. 31 is based.

(41) Dominion Bureau of Statistics. Census of Canada: Population. No. 92-539. "Counties & Sub-divisions, No. 92-615, "Census Tracts".

(42) Stone, Leroy O., "Urban Development in Canada". Ottawa, Dominion Bureau of Statistics, 1967 (one of a series of 1961 census monographs).

(43) The Financial Post. "Survey of Matrix, 1963-69". Toronto Maclean Hunter.

(44) Hoyt, Homer, "Growth of Cities From 1800 to 1960 and Forecasts to Year 2000". Land Economics.

(45) Fisher, Charles B., "Potential for Technologically and Research Oriented Companies in Canada". London, Canada. University of Western Ontario, Spring 1969.

(46) Baur, Raymond A., "Social Indicators", Cambridge, Mass., M.I.T. Press, 1966.

(47) Pearson, Norman. "What Price Surburbia". New Westminister, B.C. Lower Mainland Regional Planning Board, 1966.

(48) Black, A., Highway Research Board, Washington 1966. (H.R.R. NO. 207).

(49) Holroyd, E.M., Road Research Laboratory, Ottawa, Ministry of Transport, 1966 (R.R. L.Report No. 43).

(50) Abraham, W.I., "National Income and Economic Accounting", p.2.

(51) Baur, Raymond, A. Ed., "Social Indicators", Cambridge, Mass. M.I.T. Press, 1966.

(52) Hicks, John Richard, "Value and Capital", Oxford, Claredon Press, 1962.

(53) Lithwick, N.D. and Paquette, Gilles. "Urban Land Studies: A Canadian Perspective", the economics of urban land use. Toronto, Mathews, 1968.

(54) Baumol, W.J., "Welfare Economy and the Theory of the State". Cambridge, Mass.,Harvard U. Press 1952.

(55) Lowry, Ira. S., "Seven Models of Urban Development: A Structural Comparison, P3673. The Rand Corporation, Santa Monica, California. September, 1967.

(56) Lowry, Ira S., "A Model of Metropolis", memorandum RM-4035-RC. The Rand Corporation, Santa Monica, California, 1964.

(57) Lathrop and Hambury, "Journal of the American Institute of Planners", May 1965.

(58) Berry, Brian, "Commercial Structure and Commercial Blight, Retail Patterns and Processes in the City of Chicago", Chicago 1963.

(59) The Centre for Real Estate and Urban Economics., Institute of Urban and Regional Development, "Jobs, People and Land". Berkely, University of California, 1968.

(60) Hewton, J.T., "Metropolitan Toronto Traffic Control Signal System", Proceedings of the IEEE, April 1968, Vol. 56, No. 4.

(61) Hewton, J.T., "Metropolitan Toronto Traffic Surveillance and Control System". Civil Engineering - ASCE, Feb. 1969.

(62) Wiltshire, R.L., "Computer Traffic Control in Texas", Traffic Engineering and Control. Feb. 1969, Vol. 10, No. 10.

(63) Wilbur, Smith & Associates, "Transportation and Parking in Tomorrow's Cities". The Automobile Manufacture's Association, 1966.

(64) Blumenfeld, Hans, "Urban and Social Economic Development". An advance position paper for the Canadian Federation of Mayors and Municipalities, 1969 Urban Transportation Conference.

(65) Roth, Gabriel. "Paying for Roads", Penguin Books, 1967.

(66) Meyer, John R. Urban Transportation, Chapter 2 of "The Metropolitan Enigma", Harvard U. Press. 1968.

(67) Land & Soberman. "Urban Rail Transit, Its Economics and Technology", M.I.T. Press. 1964.

(68) Burco, Robert A. and Curry, David A., "Future Urban Transportation Systems: Impacts on Urban Life and Form". Menlo Park, California, Stanford Research Institute, 1968 Final Report #2.

(69) WABCO., "Study of Evolutionary Urban Transportation", 1968. Vol. 1.

(70) Tipping, D.B., "Time Savings in Transport Studies", The Economic Journal. December, 1968.

(71) Harris, Britton, "Quantitative Models of Urban Development". Issues in urban economics.

(72) N.D. Lea and Associates, "Automated Taxi Transit", Report to Minister of Highways, British Columbia, December, 1967.

(73) Encyclopedia Britannica, 13th edition.

(74) Meyer, Kain, Whol, "The Urban Transportation Problem", Cambridge, Mass. Harvard University Press, 1965.

(75) Doxiadis, Constantinos A., "Ekistics, An Introduction to the Science of Human Settlements", Hutchinson of London 1968.

(76) Lea, N.D. & Tanton, M.S., "Optimum Rate of Investment in Urban Roads". Proceedings of 1966 CGRA Annual Convention.

(77) Lea, N.D., "Urban Goods Movements in Canada - Information Sources and Requirements". Paper presented at Highway Research Board Commodity Flow Conference. Dec. 6-9, 1970. Warrenton, Virginia.

(78) Proceeding of conference referred to in (77) and in particular, bibliographies.
Prepared by: - Wilbur Smith and Associates
- U.S. Office of Highway Planning

(79) O.E.C.D., "The Urban Movement of Goods". Proceedings of the Third Technology Assessment Review. Oct. 1970.

(80) Bates, Malcolm V., "Goods Movement by Truck in the Central Areas of Canadian Cities". Canadian Trucking Association, 1970.

(81) Dominion Bureau of Statistics., "Municipal Government Finance". 1965. DBS No. 68-204.

(82) Kahn, H., Wiener, A.J., "The Year 2000: A Framework for Speculation on the Next Thirty Years", MacMillan & Co., 1967.

(83) Fisher, Moore Robert., "The Metropolis is Modern Life", Doubleday & Co., 1955.

(84) United Nations Yearbook of National Accounts Statistics, 1969, Volume II, "International Tables".

(85) Doxiadis, C.A., "Man's Movement and his Settlements". Ekistics, May 1970, p296.

(86) Progressive Architecture, April 1968.

(87) Jacobs, Jane., "The Death and Life of Great American Cities". Random House, NYC, 1961. "The Economy of Cities". Random House, NYC, 1969.

(88) Hicks, J.R., "Value and Capital".

(89) Little, I.M.D., "A Critique of Welfare Economics".

(90) Weber, A., "Theory of Location".

(91) Baumol, W.J., "Welfare Economics and the Theory of the State".

ÉVALUATION DU RENDEMENT DU TRANSPORT URBAIN AU CANADA

SOMMAIRE ET CONCLUSIONS

La présente donne une idée générale de l'accroissement phénoménal et des changements profonds que connaîtront les villes canadiennes d'ici la fin du vingtième siècle ainsi que des avantages sociaux et économiques que les systèmes de transport pourront représenter. Dans ce chapître, (Sommaire et Conclusions), nous ne nous attarderons pas aux questions de méthodologie; cela, nous l'avons fait au chapître 14. Nous ne reviendrons pas non plus sur la nouvelle théorie du transport étudiée au chapître 3, ni sur la nouvelle subdivision du sujet présentée au chapître 4, ni même sur l'utilité des nouveaux indices sociaux et économiques. Nous allons nous en tenir aux conclusions, aux découvertes et à leur importance pour les futures recherches et l'élaboration de lignes de conduite. Les rubriques des différentes sections sont les suivantes:

SOMMAIRE ET CONCLUSIONS

24.1 SOMMAIRE DES DECOUVERTES

Le tableau 24 tl donne un sommaire très condensé mais complet des conclusions de l'étude.

Ce tableau nous renseigne sur toutes les améliorations pratiques du transport urbain au Canada ainsi que sur leurs effets tant sociaux qu'économiques. Les données sont plus ou moins précises mais l'ensemble du tableau nous permet de reconnaître les renseignements auxquels on peut le moins se fier.

Il faut prendre soin de ne pas compter deux fois les même avantages en les additionnant. De plus, certains éléments ne peuvent pas s'additionner; par exemple

- Camionnage + Nouvelle technologie
- Grandes voies de communication & Autoroutes + Nouvelle technologie

D'autre part, il est possible de combiner certains éléments pour obtenir des avantages plus grands que leur somme totale. Le meilleur exemple en est

- Corridors + Grandes voies de communication & Autoroutes

24.2 AMÉLIORATION SUR LE PLAN ÉCONOMIQUE

En l'an 2001, les dix plus grandes villes du Canada auront une population globale de 22 millions de personnes (55 p. 100 de la population totale du pays), par rapport à 8 millions environ en 1968 (40 p. 100 de la population totale). Il est possible quela moyenne de revenu per capita en 2001 soit d'environ $4,000, valeur de 1968, par rapport aux $2,000 en 1965. En plus, une meilleure organisation du transport peut représenter une épargne équivalant à une augmentation de revenu d'environ 10 p. 100.

On peut se demander si l'augmentation de revenu que représente la rationalisation du transport urbain est vraiment appréciable. Elle l'est sans contredit à cause de l'importance des avantages potentiels, mais aussi à cause des nombreuses façons dont on peut en jouir.

Ces épargnes potentielles suffiraient plus que largement à contrebalancer le coût de l'éducation ou des services sociaux, tels que la santé et le bien-être social. Le sujet dont il est question ici a donc une très grande portée économique.

Pour bien comprendre la polyvalence de ces avantages, il faut toutefois se rendre compte qu'ils n'augmentent pas le P.N.B. C'est le contraire qui se passe. Il s'agit avant tout d'épargnes et la première façon de les utiliser est en tant qu'épargnes ce qui a pour effet de réduire le P.N.B. Il ya plusieurs autres façons d'exploiter ces avantages:

- le coût de la production peut être diminué; les produits peuvent donc être à meilleur prix sur le marché international entraînant ainsi un accroissement de production;

- les profits peuvent être distribués d'une façon égale parmi la population qui s'en servira pour se procurer d'autres marchandises et services, y compris d'autres moyens de transport;

- les profits peuvent être distribués d'une façon spéciale parmi la population pour résoudre quelque problème social particulier, chômage ou manque de mobilité des défavorisés par exemple;

- une combinaison de ces possiblilités.

Les mesures les plus efficaces à prendre pour rationaliser les transports sur le plan économique sont les suivants:

- améliorer les réseaux de grandes voies de communications et d'autoroutes. La création de corridors de transport et une meilleure planification sont les moyens les plus efficaces pour réaliser ces améliorations;

- exploiter les progrès technologiques;

- regrouper les entreprises de comionnage et améliorer les services de livraison et d'expédition des marchandises;

- améliorer la circulation, en particulier par l'utilisation d'ordinateurs.

24.3 AMÉLIORATION SUR LE PLAN SOCIAL

En plus de permettre des épargnes qui peuvent être consacrées à des programmes sociaux, la modernisation proposée des systèmes de transport peut dans bien des cas faire un apport direct vers la réalisation d'objectifs sociaux.

Les corridors pour le transport peuvent contribuer à l'amélioration de l'environnement en sauvegardant l'unité de l'agglomération, unité qui était brisée par la construction de routes et en éliminant les bruits et la pollution de l'air des quartiers résidentiels.

Grâce à la technologie moderne, il est aussi possible de grandement améliorer l'environnement en réduisant le bruit et la pollution de l'air.

La relocalisation et l'amélioration des réseaux d'autoroutes et des grandes voies de communication, ainsi que la modernisation des techniques de direction de la circulation sont les moyens les plus efficaces de réduire le temps de voyage non productif et d'améliorer l'accessibilité. La création de corridors de transport et une nouvelle conception des infrastructures en fonction de l'environnement peuvent remédier à certains inconvénients des autoroutes, cause de désapprobation publique.

Le transport urbain a, sur le plan social, un rôle important à jouer car ce n'est qu'en l'améliorant, tant du point de vue exploitation que du point de vue technologique, que l'on parviendra à résoudre l'un des problèmes sociaux les plus graves en matière de transports, celui auquel se heurte les gens qui, à cause de leur pauvreté ou incapacité de conduire, sont désavantagés par nos systèmes de transport urbain actuels.

24.4 INTERACTION ENTRE L'UTILISATION DU SOL ET LA PLANIFICATION DU TRANSPORT

Il est évident qu'il ya un effet d'interaction entre l'aménagement du territoire et la mise en place d'un réseau de transport; il serait donc souhaitable de tenir compte de cette interaction dans la planification des transports.

24.4.1 RÉAMENAGEMENT DES CENTRES-VILLES

Depuis 20 ans, l'emploi, la population et les déplacements personnels n'ont pas varié de beaucoup dans le centre de la plupart des villes Nord-américaines. Ce n'est que dans les banlieues que la population et le nombre d'emplois ont augmenté considérablement.

L'adjectif "monstre" est peut-être trop fort pour décrire l'encombrement des centres-villes mais il est certain que cet encombrement et le prix élevé des terrains ont contribué au retard du réaménagement du centre-ville.

L'encombrement de centres-villes résulte de plusieurs facteurs:

- rues trop étroites pour les véhicules de transport modernes.

- accroissement de volume de la circulation et diminution du nombre de passagers par véhicule, la voiture particulière remplaçant le transport en commun;

- circulation plus dense suscitant des problèmes pour les piétons;

- prix trop élevé du stationnement obligeant les automobilistes à tourner en rond à la recherche d'un parc à prix raisonnable et nombre insuffisant de parcs de stationnement;

- lots relativement petits;

- installations démodées de déchargement des camions d'expédition et de réception des marchandises.

Les moyens de résoudre ce problème de transport du centre-ville sont déjà connus, mais, leur mise en application n'est pas possible dans les conditions actuelles. Il n'est nul besoin de subventions à long terme pour qu'ils deviennent applicables; ce qu'il va falloir, c'est faire preuve d'imagination et de dynamisme dans tous les secteurs de réaménagement, y compris les transports.

Le transport jouera un rôle de première importance dans ce réaménagement. Les points suivants en particulier devraient être étudiés attentivement:

- amélioration des services d'expédition et de réception des marchandises;
- regroupement des entreprises de camionnage;
- utilisation des techniques modernes dans les centres-villes;
- aménagement de voies de circulation différentes pour les piétons et les véhicules;
- rationalisation des prix de stationnement;
- rationalisation des prix de stationnement dans la rue aux heures de pointe;
- meilleure organisation de transport en commun et de la circulation en général.

24.4.2 <u>Réaménagement</u>

Une meilleure planification du réaménagement des réseaux routiers (relocalisation des grandes voies de communication et des autoroutes) entraînerait certains avantages d'ordre économique et social à long terme.

Un des meilleurs moyens d'améliorer à long terme l'espacement des voies de transport est de créer des corridors utilisables pour tous les genres de transports, y compris le transport en commun, les pipe-lines et les lignes d'énergie, aussi bien que les grandes voies de communication et les autoroutes.

Dans les quelques cas où les planificateurs avaient prévu dans leurs projets des emprises de rues ou de routes exceptionnellement larges (par exemple l'avenue Portage à Winnipeg et le 401 à Toronto) , on n'a pu que s'en féliciter au moment ou il a fallu les élargir.

Les corridors sont des espaces réservés, bien avant que le besoin s'en fasse sentir, pour la construction de routes et autres aménagements de transport. En réservant des corridors de transport, on évite la démolition d'immeubles et les bouleversements dans

la vie des gens et des communautés. C'est d'ailleurs pour éviter ces pratiques coûteuses que l'on hésite actuellement à aménager un réseau convenable d'autoroutes.

La réalisation du projet d'aménagement de corridors de transport implique

- l'amélioration des techniques de planification

- la mise au point des moyens légaux de réserver des corridors; et à un moment donné seulement

- créer un fond renouvelable pour l'achat des terrains récessaires.

24.4.3 Population urbaine

Même si ce projet-ci ne tient pas expressément compte du chiffre idéal de la population d'une ville, les conclusions auxquelles on est arrivé concernant les écarts de coût des transports par rapport à la population sont si frappants qu'on ne peut les passer sous silence. Le tableau suivant donne les prévisions pour l'an 2001;

CHIFFRE DE LA POPULATION (millions d'habitants)	COÛT DU TRANSPORT ANNUEL EN DOLLARS		
	PERSONNES	MARCHANDISES	TOTAL
0.29	293	167	460
1.22	332	235	567
5.56	436	465	901

Ces chiffres toutefois ne laissent entrevoir qu'un côté de la médaille car:

- dans les villes les plus populeuses, on substitue le transport interurbain;

- dans les villes les plus populeuses, les gens préfèrent les voyages les plus longs, même si les voyages les plus courts sont à leur portée; les voyages les plus longs leur procurent probablement des avantages qui contrebalancent la différence de prix;

- l'augmentation du coût du transport est due en partie à notre désir de bénéficier d'un meilleur service;

- partie de cette augmentation représente ce qu'il en coûte pour le transport de marchandises consommées dans des petites villes des environs.

Les techniques mises au point pour ce projet peuvent servir aux futures recherches sur ce même sujet, mais ces recherches devraient être multidisciplinaires et visées non seulement les transports mais aussi d'autres facteurs qui varient avec l'accroissement de la population d'une ville.

24.5 TRANSPORT DES GENS, VÉHICULES DE SERVICE, TRANSPORT DES MARCHANDISES

Le transport des gens représente un élément important du transport urbain, soit environ la moitié du coût du transport urbain annuel. Durant les 25 dernières années, le transport en commun a diminué de 210 passages per capita à 60 passages per capita tandis que le nombre de personnes qui voyagent par automobile a augmenté. Les services de transport en commun se heurtent actuellement à de sérieux problémes causés par la diminution de leur service et de leur clientèle et l'augmentation de leurs dépenses. Nous croyons que les mesures que l'on est sur le point de prendre permettront au moins aux transports en commun de conserver peur clientèle à son volume actuel. L'amélioration du service leur permettrait aussi de regagner du terrain mais seule la technologie moderne ramènera les gens en grand nombre au transport en commun. En établissant le plan d'aide au transport en commun, il est important d'identifier clairement les buts sociaux poursuivis par cette forme de transport. Il est toujours possible de soupeser les besoins sociaux, accès à l'endroit du travail pour les personnes à faibles revenus, accès aux commodités de l'existence pour les gens infirmes et âgés, ou encore accès aux écoles, par exemple; on peut ensuite chercher des solutions et en financer le réalisation.

On n'a jamais accordé une place suffisante aux véhicules de service dans le transport urbain. Les ambulance, les camions de pompier, les véhicules d'entretien des lignes électriques et téléphoniques et autres véhicules du même genre, au contraire des automobilistes qui peuvent se tourner vers c'autres

modes de transport, ne peuvent faire autrement que d'emprunter les routes et les rues. Il faut donc tenir compte des besoins particuliers de ces véhicules dans la planification du transport urbain.

Le transport des denrées et autres marchandises représente environ la moitié du transport urbain. La plupart des avantages économiques provenant de la construction des grandes voies de communication, des autoroutes et des corridors, par exemple sont attribuables à la plus grande efficacité du transport de marchandises. Parmi les améliorations qui méritent une attention toute particulière on compte;

- le regroupement des entreprises de camionnage, expéditions et têtes de lignes.

- l'amélioration des services d'expédition et de réception et simplification du travail d'écriture.

24.6 GOUVERNEMENT ET FINANCES

Les questions de gouvernement et de finances n'entrent pas vraiment dans le cadre de ce projet. Cependant, lors de cette étude, on a découvert certains faits qui ont une grande importance en maitière de gouvernement et de finances. Nous n'en parlons ici que pour mettre en relief d'autres faits de plus grande importance.

En ce moment, il y a un écart considérable entre les recommandations faites à la suite d'études économiques et techniques et les mesures qui sont prises. Une des raisons en est que les organisations gouvernementales ne peuvent facilement s'adapter au rythme incroyable de l'accroissement géographique des villes, accroissement qui continuera encore longtemps et qui doit être pris en considération si l'on veut réaliser les avantages du transport urbain à long terme.

Le Canada est l'un des pays les plus avancés de monde en ce qui concerne le développement des structures gouvernementales régionales et il semble qu'il nous faille continuer dans cette direction pour les besoins de la planification du transport urbain.

On entend souvent dire que la participation des pouvoirs municipaux aux dépenses entraînées par le transport urbain dépasse de beaucoup les capacités financières de la municipalité. Il semble nécessaire d'évaluer de nouveau le financement du transport urbain.

Une chose est évidente. L'usager de la route est prêt à payer un prix maximum pour avoir de bonnes routes. Tout ce qu'il demande c'est que le gouvernement lui vende ce qu'il veut. Le partage des dépenses par plusieurs niveaux gouvernementaux doit être considéré comme l'un des éléments du problème; la solution réside dans un changement de la structure fiscale. La situation se présente différemment en ce qui concerne le financement du transport en commun.

L'usager du transport en commun n'est pas prêt à payer un prix maximum et il serait donc nécessaire d'évaluer soigneusement les buts et avantages sociaux afin d'être à même d'organiser un système plus rationnel et d'obtenir une meilleure participation financière.

24.7 PROGRAMMES DE RECHERCHES

Les conclusions de l'étude peuvent servir de base à une rationalisation des programmes d'ensemble de recherches sur le transport urbain. Nous avons prouvé ceci en préparant une première liste de programmes de recherches prioritaires fondée sur les bénéfices et probabilités anticipés de chaque programme.

Les sujets de recherche suivants comptent parmi ceux qui ont été indentifiés lors de l'étude.

24.7.1 Choix d'indices sociaux

On peut faire une étude technique des facteurs sociaux importants à partir des aspects économiques du bien-être social ou à partir d'indices sociaux Cette dernière façon d'aborder la question est en ce moment la meilleure car elle permettra probable-

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Voir, par exemple la première conférence canadienne sur le transport urbain de la Fédération canadienne des maires et des municipalités: Conférence régionale p. 116; et ailleurs dans le compte-rendu et dans les communications.

ment de rétablir plus rapidement le dialogue entre les techniciens et les politiciens. Les indices sociaux peuvent suffire en attendant que la sociologie analytique et l'analyse économique soient assez poussées pour contribuer à la solution des ces problémes. Dans l'étude, on a donc commencer à utiliser les indices sociaux. Il est cependant nécessaire d'accorder une priorité à la recherche sur les indices sociaux quantitatifs concernant les objectifs humains et la qualité de l'environnement social.

Notre incapacité actuelle à évaluer notre milieu social se fait sentir dans le fait que nous ne pouvons pas d'aucune manière dire si l'agglomération A est meilleure ou pire que l'agglomération B en tant qu'habitat. Tout compte fait, la planification de l'utilisation du sol et du transport dépend de l'intuition et du jugement personnel de quelques personnes seulement. Il n'est pas possible de mettre au point un procédé de planification plus scientifique jusqu' à ce qu'on recueille des données quantitatives concernant les réactions des gens vis-à-vis différents modes de vie et de transport.

24.7.2 ÉVALUER L'IMPACT SOCIAL DE TRANSPORT EN COMMUN

Ce qui nécessite surtout une recherche sociale, c'est probablement l'impact du transport en commun. Ce sont surtout des avantages sociaux que peut apporter l'amélioration de transport en commun. Certaines catégories de gens - notamment les pauvres, les enfants et les infirmes qui ne peuvent pas voyager par automobile, pourront surtout en bénéficier. Certains nouveaux moyens de transport en commun très dispendieux se sont avérés inefficaces pour venir en aide à ces gens qui en ont le plus besoin. Il faudrait done faire des recherches pour évaluer l'impact social des différentes propositions de transport en commun sur les divers secteurs de la communauté, particulièrement les désavantagés.

24.7.3 CRÉER DES QUARTIERS EXPÉRIMENTAUX

Les facteurs qui impriment un caractére aux quartiers résidentiels sont les suivants:

- le code du bâtiment et autres règlements,
- le lotissement,
- les moyens de transport présents et futurs.

La meilleure façon d'améliorer une ville est de réaménager ou de reconstruire les quartiers résidentiels afin de permettre un meilleur mode de vie. C'est en combinant un certain nombre d'éléments, y compris le transport, auxquels on a apporté des améliorations, que l'on peut atteindre ce but. Mais, encore faudra-t-il être sûr que ce quartier est "meilleur" une fois refait. Nous ne le sommes pas maintenant. Pour nous aider à résoudre ce problème, il faudrait concevoir et construire quelques quartiers expérimentaux en contrôlant soigneusement certains facteurs pour mesurer le coût (investissement, entretien et exploitation), la valeur sociale et la réaction du public. Il faudrait ensuite comparer ces quartiers à ceux qui existent actuellement et parmi lesquels on a choisi des groupes contrôles. La demande et l'attitude des usagers serviraient d'indice de qualité.

Les propositions suivantes concernant le transport doivent être étudiées:

- Normes concernant les routes d'accès modifiées pour diminuer les dépenses, mais prévoyant l'égouttement et l'aménagement paysager;

- <u>Nouveaux systèmes de transport en commun pour les quartiers</u>, comprenant les "services d'autobus par téléphone", les mini-autobus sur commande ou les mini-autos loués;

- <u>Système fictif de transport en commun inter-quartier</u>. Un nouveau système de transport en commun inter-quartier sera peut-être nécessaire pour faire ressortir les principales caractéristiques d'un quartier expérimental. Il ne serait pas pratique de construire un réseau de transport en commun entre tous les quartiers d'une ville quand on ne veut faire l'étude que d'un seul quartier, mais il serait possible, avec l'imagination et les fonds voulus, d'inventer un système qui réponde à l'idée que s'en font les habitants du quartier expérimental.

24.7.4 Recherche sur le transport des marchandises

Le transport des marchandises dans la ville est un sujet qui a été un peu négligé sur le plan de la recherche. Pourtant, il est d'une grande importance d'étudier sérieusement les points suivants:

- Amélioration des services d'expéditions et de réception des marchandises
- Amélioration des camions
- Regroupement des entreprises de camionnage
- Regroupement des installations d'expédition
- Regroupement des têtes de ligne
- Frais de camionnage
- Demande de transport des marchandises.

24.7.5 Mise au point de mouvelles techniques pour l'aménagement de corridors de transport

Pour être à même de créer de nouvelles techniques pour l'aménagement de corridors de transport il faudrait faire des avant-projets détaillés de corridors pour deux villes canadiennes. Il faudrait poursuivre, séparément ou dans le cadre d'un projet d'étude sur les corridors, les recherches sur la localisation des grandes voies de communication et des autoroutes.

24.7.6 L'économie foncière

L'économie foncière ne peut contribuer comme elle devrait à la planification du transport urbain, particulièrement lorsqu'il s'agit de la valeur des terrains, par rapport à leur prix, leur accessibilité et l'action du gouvernement, y compris la réservation des corridors de transport. Il serait nécessaire de faire une étude sur des relations entre ces facteurs après avoir receuilli des données empiriques canadiennes.

24.7.7 Améliorer la planification du transport

L'application des techniques d'analyse de système qui divisent par catégories les dépenses occasionnées par le transport (transport des voyageurs et

transport des marchandises, par exemple) et qui donnent des renseignements significatifs sous forme d'indices sociaux et économiques constitue un progrès actuel très prometteur dans le domaine de la planification du transport. On a employé cette méthode dans la présente étude; il faudrait cependant continuer de l'améliorer.

On pourrait peut-être élaborer des projets pilotes de planification urbaine qui prévoieraient la vérification et la réalisation des systèmes théoriques de transport amélioré. Pour ceci, il faudrait étudier la société par secteur. Au niveau national, certains points sont à considérer lors de la planification du transport. Ce sont

- les différences régionales
- les normes nationales de sécurité routière
- les normes nationales de fabrication
- la distribution des données
- la coordination des recherches

Ces points mettent en relief l'importance pour le pays d'une refonte des techniques d'analyse des systèmes de transport urbain.

24.7.8 Taille, forme et densité des villes, etc.

Dans l'étude, nous avons tenu compte de la taille, la forme et la densité de la ville. En effet, dans la section 24.4.3, on a tiré des conclusions à la suite d'une recherche sur la taille des villes. On a aussi découvert qu'une ville de forme circulaire offre plus d'avantages du point de vue du transport et que, plus la population est dense, plus ces avantages sont prononcés. Il faudrait approfondir ces questions. Ce serait toutefois une erreur que de juger une ville uniquement sous l'angle des transports. Ainsi, il faudrait entreprendre une étude plus global de la ville dont le transport serait un des élément importants.

24.7.9 Nouvelle technologie

On peut augmenter le rendement à la fois sur le plan social et économique en faisant appel à la nouvelle technologie du transport urbain. Ce domaine de recherche est potentiellement très fructueux et pourrait compléter la présente étude.